CANADA

DEPARTMENT OF MINES AND RESOURCES
LANDS, PARKS AND FORESTS BRANCH
DOMINION FOREST SERVICE

Sample Plot Methods

BY

W. M. ROBERTSON

AND

G. A. MULLOY

OTTAWA
EDMOND CLOUTIER, C.M.G., B.A., L.Ph.,
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
CONTROLLER OF STATIONERY
1946

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TABLE OF CONTENTS

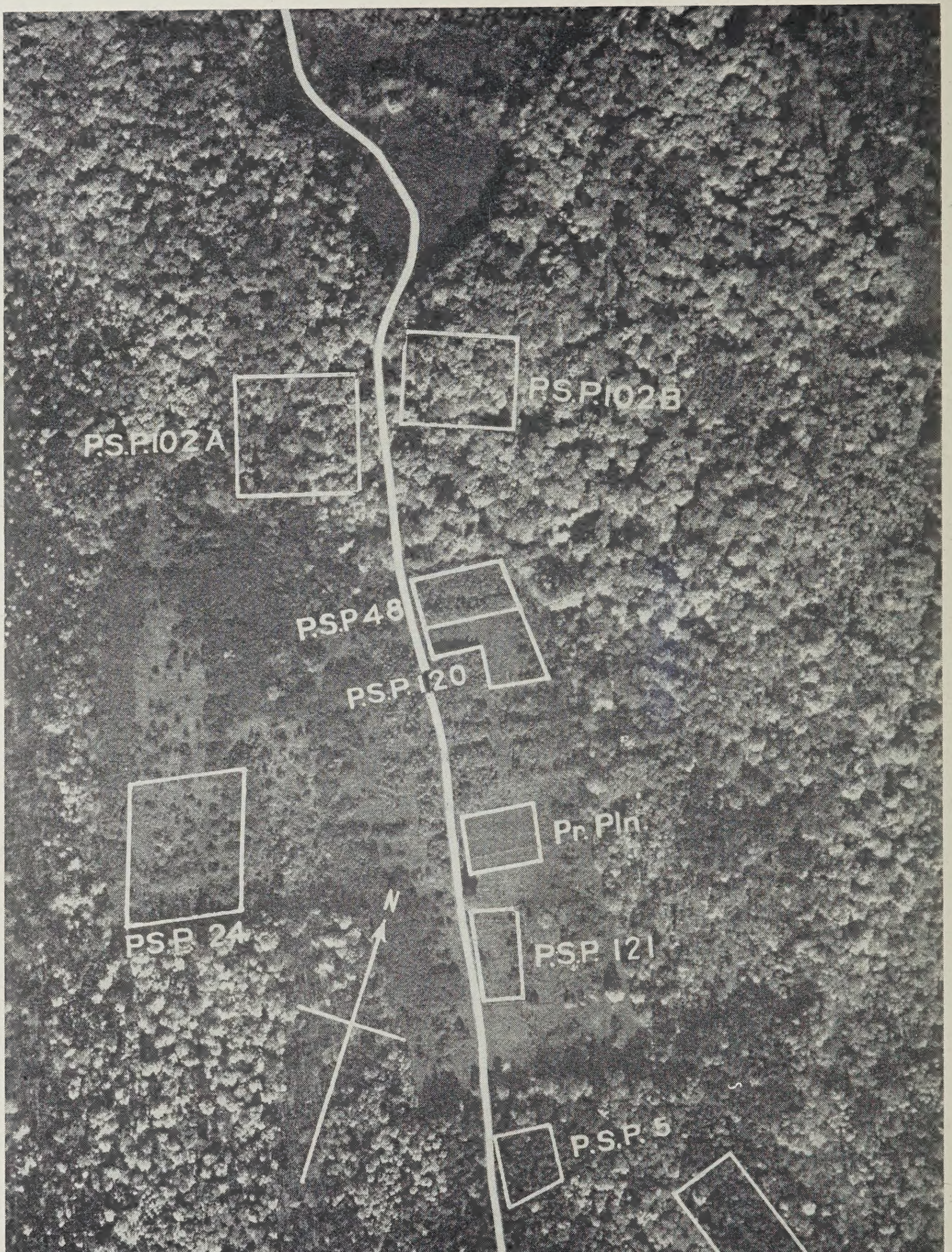
57631—1½

FOREWORD

It is now generally recognized that scientific workers must be allowed considerable freedom in the development of both field and office technique, as indicated by the particular line of investigation being followed. This freedom must apply particularly to analysis of the data secured, and to presentation of the deductions and conclusions drawn therefrom. Nevertheless, much valuable time may be saved, and data may be collected and compiled in a more readily comparable form if, up to a certain point, a standard routine is adopted.

With this end in view, there was issued in 1924 the FOREST RESEARCH MANUAL, dealing with field methods in forest research. The intervening years have witnessed a considerable extension and development in this field, and many modifications and improvements have resulted. The present publication is designed to cover particularly the subject of sample plot methods, also to standardize methods of compiling field data. Subsequent use of these data will, of course, lie within the discretion of those pursuing any specialized line of research.

57631—2


P.S.P.102 B
P.S.P.102 A
P.S.P 48
P.S.P. 120
Pr. Pln.
P.S.P. 24
N
P.S.P. 121
P.S.P. 5
P.S.P.7

SAMPLE PLOT METHODS

Introduction

The forest universe is so extensive that, even for details of inventory, sampling is necessary. It is true that such marked progress has been made in recent years in the development of methods of aerial cruising and photography that the making of volumetric estimates of the entire forest universe by this means is within the realm of possibility. Classification into cover types, age groups, site types, and density classes from aerial photographs is already possible. However, dependence must still be placed on ground sampling methods for details of the understory and reproduction, and for data on growth. By sampling methods alone can information be obtained on the development of the forest, and on the effect of silvicultural treatment.

Forest research may be conducted either by empirical methods or by fundamental studies of the basic sciences (2). Because of the long time element involved in fundamental research, problems pressing for an early answer must first be attacked by empirical methods. However, provision should be made to supplement empirical studies by a carefully prepared program of fundamental research. For either method the sample plot is the primary medium for collection of necessary data.

Types of Sample Plots

Permanent Sample Plots are small representative areas on which developments are followed by means of repeated remeasurements or examinations continuing through a period usually exceeding ten years (49). Because of the relatively high cost of establishing permanent sample plots, and the consequent tendency to limit their number, their use is confined largely to studies on small experimental areas in intermediate cuttings, and to plantations.

Transect Sample Plots are chains of sections of uniform size, usually contiguous; each section is a unit in itself, from which complete records are taken. It may be temporary, but is usually permanent. The sections may be rectangular or circular, but must never be irregular in shape. The records are less comprehensive than those for permanent sample plots and are therefore adapted to studies of extensive areas.

Line Plots are plots of uniform size, usually one square chain, either rectangular or circular in shape, distributed at regular intervals along parallel compass lines spaced at regular intervals over a forested area.

Temporary, or Single-examination Plots are generally similar to permanent sample plots, but data therefrom are recorded once only, and boundaries and trees are, therefore, not permanently marked. Their particular value is in taking density and yield data, and in sampling reproduction.

Sub-plots or Quadrats are small divisions laid out within sample plots for the purpose of recording reproduction too abundant to be tallied for the whole plot, or for studying the effect of special conditions or treatment, notably treatment of seed-bed (49).

Raunkiaer Plots are areas of one-tenth metre, delimited by a metallic ring subdivided internally. The ring is dropped at fixed intervals, and a sample count of ground vegetation made within its circumference.

Frontispiece—Aerial vertical photograph showing a series of permanent sample plots, and the road to which they have been tied. The photograph was taken in autumn, consequently softwoods and hardwoods can be readily differentiated. Cover type boundaries can be clearly distinguished, trees with crowns in the upper story can be counted, and height can be measured from shadows. (Photo R.C.A.F. A829-41).

57631—2½

Control Plots are those established to form a base or norm with which the response of treated plots may be compared (49). They are not always required with transect sample plots.

The Surround is the area immediately surrounding a permanent sample plot, treated in the same way as the plot proper, to ensure like conditions throughout the plot area. The width of the surround should be not less than two-thirds the height of the dominant trees.

Project Classification

A comprehensive classification for forest research projects to provide for orderly development, prosecution, and recording of projects undertaken, and to indicate the fields in which future activities should be directed, is essential. The classification hereunder, adopted by the Dominion Forest Service (13), is a modification of that prepared by the National Research Council of the United States.

I. Forest Botany

- A. Taxonomy
- B. Anatomy and Morphology
- C. Physiology
- D. Phenology
- E. Genetics
    - *(a)* Source of Material
    - *(b)* Tree Breeding
    - *(c)* Cytogenetics
    - *(d)* Wood Technology
    - *(e)* Vegetative Propagation
    - *(f)* Pathology
    - *(g)* Zoology
    - *(h)* General

II. Forest Ecology

- A. Geography and Description
- B. Forest Types
    - *(a)* Site-types
    - *(b)* Cover-types
- C. Enumeration Surveys
- D. Studies in Succession
- E. Silvics of Individual Species
- F. Site Factors
    - *(a)* Climatic
    - *(b)* Edaphic
    - *(c)* Biotic
- G. Introduction of Exotics

III. Silviculture

- A. Seeding and Planting
    - *(a)* Seed
    - *(b)* Direct Seeding
    - *(c)* Nursery Practice
    - *(d)* Planting Practice
- B. Intermediate Cuttings
    - *(a)* Cleanings
    - *(b)* Thinnings
    - *(c)* Pruning
    - *(d)* Improvement Cutting
    - *(e)* Girdling

C. Harvest Cutting
  (a) Successional
  (b) Reproduction

IV. Forest Mensuration
A. Volume, Growth and Yield
B. Technique

V. Forest Influences
Effect of Forest on:—
A. Climate
B. Soil
C. Water
D. Animals

VI. Forest Protection
A. Fire
  (a) Prevention
  (b) Detection
  (c) Control
  (d) Damage and Effect of Fires
  (e) Statistics
B. Disease
C. Biotic
  (a) Insects
  (b) Animals
  (c) Man
D. Climate

VII. Forest Administration
A. Working and Management Plans
B. Timber Disposal
C. Engineering
D. Recreation

VIII. Forest Economics
A. Inventory
B. Marketing and Prices

IX. Wood Technology

X. Forest Products Utilization
A. Methods and Costs
B. Little-used Species and Products

This classification, modified to suit conditions in Canada, is wide in scope, providing not only for purely biological and silvicultural projects in the fields of Botany, Ecology, Silviculture, Mensuration, and Influences, but also for related projects which involve the co-operation of the divisions concerned with Protection, Administration, Economics, Technology, and Utilization.

While no one experiment station can possibly cover the entire field of forest research, each station should follow out the standard classification, in the interest of uniformity.

Each project should be assigned a number and descriptive title and should be registered in numerical sequence in a project register. It will often be found that a single project may embrace more than one experiment. All such experiments should bear the one project number and title but should also be given individual experiment numbers. Conversely, a single experiment or series of experiments or plots may provide data for more than one project, and should be shown under each of the projects concerned.

A separate file should be kept for the descriptive records of each project. Besides title, purpose, and description of project and experiments and plots concerned, brief diary notes should be added to the project records, to keep them up to date, and from which the status and progress of the project may be observed at any time.

Project Plan

Before starting any new project, a carefully considered project plan should be prepared. This should show project number, classification number, descriptive title, purpose, methods to be followed in conducting the investigation, results to be expected and within what period, application of results, and whether the project will be complete in itself or should be extended. The area should be described as to cover type, site type, density, age class, and extent. The plan should provide an estimate of the extent of time, number of staff, list of equipment, and amount of funds likely to be involved, for establishment, remeasurement, and compilation. The plan should be accompanied by type maps of the area under consideration, and should be approved by the officer responsible before any field work is undertaken.

PERMANENT SAMPLE PLOTS

The most important use for permanent sample plots is in studies of intermediate cuttings and harvest cuttings, both in natural and in planted stands, and in development of plantations. Usually these include studies of the effects of site, density, and age class, and of silvicultural cutting methods, upon growth, yield, and reproduction. In view of the time and cost involved in setting up permanent sample plots, their use will generally be restricted to intensive investigation of comparatively small experimental areas; they are not adapted to the study of large-scale cutting operations.

Field Work

Number of Plots.—In studies of effect of treatment it is essential that one or more control plots be included in each series, to provide a means of measuring the effect of treatment: however, in studies of growth and yield of untreated stands control plots are not required.

The number of plots requisite for any given experiment is three or more, depending on the number of degrees of variation to be sampled. The series should comprise one control plot, one plot in each degree of variation, with a second plot in any one degree of variation, the latter to serve as a check for the corresponding plot in the series (26).

Selection of Location.—Selecting the location for either one or a series of permanent sample plots demands careful, intelligent consideration of many factors. The purpose in establishing sample plots may be to investigate a particular forest condition, in which event the sample should represent that particular condition: more often the purpose is to obtain samples representative of the average conditions in a given stand or forest. The tendency is to select samples of conditions better than the average, particularly with respect to the distribution of the crown cover. Such factors as cover type, site type, density, age class, and stand treatment must always be kept in mind.

Not the least important requirement is to find an area or areas sufficiently large for both treated and control plots with suitable surrounds. For most studies the area of the plot and surround should be two acres or more, to provide a 50-foot surround for an acre plot.

It is more important that all plots be similar in composition and density than that they be entirely free of normal openings. Openings are to be found in the average stand and they should therefore be included in the sampling.

Accessibility of location should also be given careful consideration. Plots readily accessible cost less to establish and to remeasure than do those difficult to reach, and are also less likely to be neglected. Plots not readily accessible have little or no value for demonstration purposes.

Where studies extending over a long period are concerned, it is obviously necessary that the plots shall be protected from disturbance and fire. Areas already set aside for experimental purposes will, in most cases, afford optimum conditions in these respects, and should always be used where possible.

After a preliminary ocular selection has been made, the plots should be delineated, and the trees tallied. From the tally the stand density of each plot should be calculated and compared with that of the others in the series. Stand composition should also be compared. It may be necessary to make a number of trials before a suitable location or locations can be found for all the plots in the series. Use of a cumulative frequency curve of number of trees in diameter classes is recommended to obtain comparable plots.

The plot selected for control should be the one most representative of the area sampled, not necessarily the plot that is most heavily stocked.

Size and Shape of Plot.—The size of the plot will depend largely upon the purpose of the investigation and the nature of the stand. For studies in dense stands of saplings, an area as small as one square chain, plus the surround, may be sufficient. In general, however, the area should be not less than half an acre; a full acre is preferable. An area of one acre or an even multiple of one acre simplifies computations, since all values must ultimately be computed to an acre basis. In the interests of simplicity and accuracy it is best to have plots rectangular in shape; use of circular plots is not advisable. Dimensions commonly used for an acre plot are: 198 feet × 220 feet, 165 feet × 264 feet, or 132 feet × 330 feet. Plots longer than 330 feet are not recommended, because they are likely to include too many variations in the factors under observation. Transect sample plots have been devised for sampling such areas.

Survey of Plot.—Form 1(a) should be used for records of the plot survey, and calculations of the area. The same form may be used for tie-in survey notes, and for calculations.

Boundary lines of the plot are to be run with staff compass, or with transit if it is available (see "Instruments"). A back-sight must be read from each station for a check. Allowable difference between fore- and back-sights is fifteen minutes. All bearings should be magnetic. To avoid possibility of confusion, all linear measurements should be taken with steel tape graduated in feet and tenths. The surveyor's chain graduated in links should not be used. Single chainage is permissible, but the closure error must not be greater than 1 in 300. The closure error should be determined by calculating latitudes and departures, using Boileau's or other traverse tables and using the forward reading only.

Permanent sample plot boundaries should be measured horizontally and the data expressed in terms of horizontal area. As slope apparently influences growth, it is important that degree of slope be indicated. The area must be calculated correct to two certain places, and recorded on the form, before the establishment records may be considered complete. A properly inscribed post must be set at each corner, and referenced to two nearby witness trees. These ties should be recorded on the location map.

The boundary line should be cleared of underbrush with as little disturbance as possible to the stand. Boundary-line trees should not be removed. When more than half the bole of boundary-line trees lies within the plot, they should be included, but not otherwise. If trees close to, but outside, the boundary are painted on the inner side, it is helpful in relocating the line.

SURVEY (PLOT)

FORM 1(a)

SAMPLE PLOT No. 1 GENERAL LOCALITY Petawawa For. Ex. Sta. Headqrts. Blk. AREA 0.841 Acre

DETAILS OF LOCATION This Plot is situated about ½ mile north east of a tie post which has been planted on the north side of the Pembroke Road ¼ mile south east of Wienegan Cr. Bridge

MEASUREMENTS BY Fensom NOTES BY Robertson DATE July 13/27 CHECKED BY Bickerstaff DATE May 1942

STA	COURSE	MAGNETIC BEARING	DISTANCE FT & TENTHS	LATITUDES		DEPARTURES		BALANCED LATITUDES AND DEPARTURES			
				NORTH	SOUTH	EAST	WEST	NORTH	SOUTH	EAST	WEST
A	A B	N86°15'W	116.1	7.60			115.90	7.61			115.78
B	B - A	S86°00'E									
	B - C	S6°15'W	155.5		154.57		16.93		154.56		16.77
C	C - B	N6°00'E									
	C - D	S86°15'E	250.5		16.38	249.96			16.36	250.25	
D	D - C	N86°00'W									
	D - E	N 6°00'E	121.5	120.83		12.70		120.84		12.83	
E	E - D	S 6°00'W									
	E A	N72°00W	137.4	42.46			130.67	42.47			130.53
A	A E	S 72°15'E									
		Totals	781.0	170.89	170.95	262.66	263.50	170.92	170.92	263.08	263.08
			Error: 1 in 860								

SURVEY CALCULATED BY Fensom DATE July 15, 1927 CHECKED BY Bickerstaff DATE May 1942

(Calculation of area on reverse side)

CALCULATION OF AREA

FORM 1(a) Reverse

P.S.P #1

COURSE	BEARING	LATITUDES		DEPARTURES		DOUBLE LONGITUDE	PRODUCTS	
		NORTH	SOUTH	EAST	WEST		NORTH	SOUTH
C – D	S86°15'E		16.36	250.23		250.23		4093.76
D - E	N6°00'E	120.84		12.83		513.29	62015.96	
E - A	N72°00'W	42.47			130.52	395.60	16801.13	
A - B	N86°15'W	7.61			115.78	149.30	1136.17	
B - C	S 6°15'W		154.56		16.76	16.76		2590.43
							79953.26	6684.19
							6684.19	
							73269.07	

$$\frac{73269.07}{2} = 36634.53 \text{ Sq. ft.}$$

$$\frac{36634.53}{43560} = 0.841 \text{ Acre}$$

AREA CALCULATED BY A. Brown DATE Aug 1927 CHECKED BY T. Jones DATE Aug. 1927.

FORM 1 (b)

SURVEY (TIE)

SAMPLE PLOT No. *1* GENERAL LOCALITY *Petawawa For. Ex. Sta. Headqrts Blk.* AREA *0.841* Acre

DETAILS OF LOCATION *Tie Post on the north side of the Pembroke road 1/4 mile south east of Winnegan Cr. Bridge*

MEASUREMENTS BY *Fensom* NOTES BY *Robertson* DATE *July 13, 1927* CHECKED BY *Bickerstaff* DATE *July 1927*

STA.	COURSE	MAGNETIC BEARING	DISTANCE FT. & TENTHS	LATITUDES		DEPARTURES		BALANCED LATITUDES AND DEPARTURES			
				NORTH	SOUTH	EAST	WEST	NORTH	SOUTH	EAST	WEST
0	Tie Post										
0	0 – 1	N40°45′E	501.6	380.1		327.5					
1	1 – 2	N79°15′E	336.6	62.7		330.7					
2	2 – 3	N37°00′E	462.4	369.3		278.3					
3	3 – C	N65°30′E	330.0	136.9		300.3					
				949.0		1,236.8					
	C – Corner post at the S.W. Cor. of P.S.P. # 1										

SURVEY CALCULATED BY *Fensom* DATE *July 1927* CHECKED BY *Bickerstaff* DATE *May 1942*

Tie of Plot. Form 1 (b).—Every plot must be tied in by surveyor's compass or transit to a tie-post at the side of the road or other well-defined route of approach, the location of which can be found from the "details of location". Where two or more plots are in the same vicinity it is permissible to tie the group together with a single plot of the group tied to the tie-post (See Form 2, p. 27).

The primary purpose of the tie is to enable anyone to relocate the plot at any time. Obviously the line bearings and chainage should read from the tie post to the plot. The procedure should be to traverse the trail, regularly used to reach the plot, from road to plot. If a more direct route for the tie seems desirable, it should be blazed from plot to road, and then traversed from road to plot. Sighting stations on the tie-line should be marked with a numbered picket. Fore-sights only need be read. Chainage should be in feet and tenths. The tie-post should be firmly set in a conspicuous position, and witnessed.

A second purpose of the tie is to enable accurate orientation of the plot on the cover-type map. For this purpose it is necessary that the tie-post on the road be tied to an approved base line. This secondary tie, however, may rightfully be considered the responsibility of the surveys division responsible for the establishment of the base line.

Numbering Trees.—Whether tagging is preferable to painting numbers is a controversial subject (6, 11, 31). Tags involve cost of manufacture: they are usually small and difficult to see: if the nails enter the cambium layer they soon become over-grown and must be withdrawn periodically; nails are injurious to small trees, particularly hardwoods, and may cause abnormal growth; if the tree ultimately reaches a sawmill, they may damage the saws.

Painted numbers require more equipment and more time in the field; they are not suitable for trees of sapling size: there is a tendency for numbers to flake off the bark: they are difficult to apply to certain species, such as birch and poplar.

The possibilities of plywood discs to replace aluminium tags are being investigated. In the meantime it is optional whether tags or painted numbers be used to identify the trees.

Before numbering, the plot should be subdivided into 20-foot strips by means of string run from permanent pickets placed on two opposite boundaries. Trees should be numbered progressively down one strip and up the next, the numbers facing the investigators.

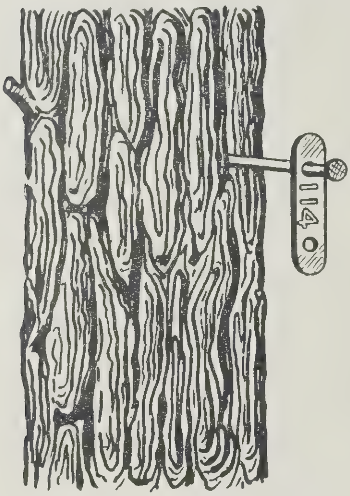


FIGURE 1.—Proper method of affixing tree tag.

Tags should be attached with copper nails, which should not be driven into the cambium layer if the bark is thick enough to retain the nail. The nail should be placed at breast height with the head slightly lower than the point, so that the tag will not rest against the tree, otherwise it is likely to become embedded in the bark. When numbers are painted, the breast-height point should be indicated by a painted horizontal line.

Heretofore the practice has been to number all trees over 0·5 inch D.B.H. (51). Study of sample plot stand tables suggests that the increased information and accuracy obtained by numbering and recording data for each sapling, as against a simple tally in diameter classes, does not justify the greatly increased cost. Although 50 to 75 per cent of the trees in plots in the 40-year age-class are saplings, their basal area and volume is in the neighbourhood of only 10 per cent of the stand. Ten years later, by reason of growth, and more particularly because of mortality in the sapling class, the numerical proportion of saplings drops to about 20 per cent, and the volume to less than 5 per cent of the stand. The difference between total basal area of a large number of trees determined from individual measurements, and that determined from a grouping into one-inch diameter classes, is insignificant. The possible error due to omission or double tally of an occasional sapling is also relatively unimportant. As most saplings remain in the suppressed crown class, comparatively little detail is lost in study of crown-class distribution.

It is concluded, therefore, that numbering of trees may be confined to those over 3·5 inches D.B.H. Trees 0·6 inch to 3·5 inches should be recorded by dot tally in one-inch diameter classes, separating the tally for each 20-foot strip.

Mapping Trees.—A field map showing location of trees, their species, and diameter to scale serves several valuable purposes. It is a means of relocating the trees for remeasurement, even if numbers have gone astray. The distribution of the stand, and areas under- or overstocked, are readily seen from the map and therefore it is an aid in selecting trees for removal. It provides basic data for the preparation of crown-class maps.

From the survey notes, plot the boundaries of the sample plot on cross-section paper to a scale of 10 feet per inch, with the most northerly side at the top. Subdivide the plot into 20-foot strips, as was done on the ground when tagging the trees.

Stretch a 100-foot tape down the centre of each strip. Then have one man locate the position of each tree as so many feet north (read from tape), and so many feet east or west of the centre line (measured by a 5-foot pole). He will call these distances to the mapper and will give him the number of the tree, if it is tagged, or the species if a sapling. The mapper will indicate the position by a dot and tree number, or sapling species symbol. It is preferable to proceed up one strip and down the next, just as in tagging. The position of reproduction subplots and the position of corner witness trees should be shown. (See map inside back cover.)

PHOTO. 1.—Permanent sample plot divided by strings into twenty-foot strips before tagging, tallying, and mapping location of trees. (Photo. No. 19881).

PHOTO. 2.—Mapping location of trees within a strip. Distance from boundary of plot is read from a tape run down centre of strip. Distance right or left of tape is measured by means of a pole. (Photo. No. 20399).

Major interest is centred in the trees that are likely to constitute the first mature crop, the present dominant trees. For example, yield tables show that a fully stocked stand of white pine, at 100 years of age, contains 250 trees per acre. Therefore, before starting to measure diameters, the 250 trees per acre that seem likely to constitute the first mature crop should be selected and clearly marked with a broad band of paint: the number may vary for other species.

Diameter Record. Numbered Trees, Form 3.—While surveying, mapping, and tagging of trees may be done at any season of the year, no measurements of diameters or heights should be undertaken during the season of significant growth, that is, in Canada, between the first of June and the middle of August.

The trees should be listed in strictly numerical sequence, and the standard symbols for species should always be used (Appendix II). Diameter breast height should be measured with diameter tape (5, 37, 49) and read in inches to two places of decimals. Each measurement should be made twice, and the second reading should check with the first: if it does not check closely, further measurements should be made. The tree class (crown class) should always be entered in column provided. Notes on banded trees, trees to be removed, abnormalities, dead trees, etc., may be kept in remarks column.

The first section only of each sheet should be used for the records taken at time of establishment of plot. The other sections are provided for subsequent periodic remeasurement data.

Diameter Record. Unnumbered Trees, Form 4.—Records of saplings should be taken by dot or by stroke tally, separating species and diameter classes. A separate tally should be taken for each strip. All trees dead at time of establishment should be blazed or removed, but no dead trees should be tallied in the first measurement. Blazing the dead trees will obviate their inclusion with trees dying during any remeasurement interval.

Height Record. Form 5.—In the past, insufficient stress has been laid on the taking of height records. Since the relationship between diameter growth and height growth is constantly changing, at least in even-aged stands of intolerant species, it follows that the form of the diameter-height curve is always changing, and this in turn is reflected in volume growth.

It is difficult to read heights within a limit of error of one foot and therefore dependence must be placed on the average of a large number of measurements to correct this error. It is also important that height measurements be taken on the same trees at each remeasurement, and that these heights be checked against those of the previous measurement. Where the number of trees of specified species is insufficient to provide a diameter-height curve, the height of such trees should be measured and their volume calculated individually on actual diameter and height.

To ensure the taking of an adequate number of well-distributed trees and the measuring of the same trees at each periodic remeasurement, and to provide for back-checking of the measurements, all trees numbered for diameter measurements should be listed in numerical sequence on the form. These data may be copied from Form 3 in the office, before leaving for the field. Even although it is unlikely that all trees measured for diameter can be measured for height, the short time required to list them will be amply repaid, not only in the taking of more consistent records, but in subsequent compilation.

After investigation of many instruments, none has yet been found to be as satisfactory as the Abney hand level set on a tripod (49) and this instrument with percentage arc has been generally adopted as standard equipment for measuring tree heights.

TREE-DIAMETER RECORD

(DIAMETERS IN INCHES AND HUNDREDTHS)

FORM 3

PERMANENT SAMPLE PLOT No. 1 LOCALITY Petawawa

STRIP No.	TREE No.	SPECIES	MEAS. BY T. Smith NOTES BY R.A.T. DATE Aug 12/18 D.B.H. (Inches)	CHECK	TREE-CLASS	REMARKS	MEAS. BY R. Jones NOTES BY A.B.C. DATE Aug 20/23 D.B.H. (Inches)	CHECK	TREE-CLASS	REMARKS	MEAS. BY R. Jones NOTES BY D.E.F. DATE Aug 15/28 D.B.H. (Inches)	CHECK	TREE-CLASS	REMARKS	MEAS. BY Sisam NOTES BY K.B. DATE Aug 10/33 D.B.H. (Inches)	CHECK	TREE-CLASS	REMARKS
1	1	Pw	5.90		1		6.42		1		7.41		2		7.75		2	
	2	Pw	7.50		1		8.75		1		9.36		1		9.92		1	T
	3	Pw	5.15		1		5.93		2		6.34		2		6.80		2	T
	4	Pw	8.10		1	B	9.45		1		9.97		1		10.46		1	
	5	Pw	4.60		3	Weevil	4.88		3		4.91		3		4.92		3	Dy. - T
	6	Pw	6.45		1		7.40		1		7.97		1		8.45		1	
	7	Pw	8.46		1		9.94		1		10.75		1		11.44		1	
	8	Pr	11.10		1	B	12.40		1		13.23		1		13.88		1	
	9	Pw	5.00		2		5.44		2		5.73		3		5.83		3	T
	10	Pr	10.80		1	B	12.10		1		12.86		1		13.51		1	
	11	Pw	4.59		2	Weevil	4.88		2		5.47		3		5.57		3	T
	12	Pw	4.47		2		4.86		3		4.95		3		5.11		3	T
	13	Pw	3.73		3		3.94		3		4.02		3	Dying	—			D
	14	Pw	4.74		2		5.15		3		5.44		2		5.67		2	T
	15	Pw	4.41		3	Double top	~~4.92~~ 4.59?		3	Dying	4.64 OK.		3		—			D
	16	Pw	4.92		2		5.50		2		6.03		2		6.53		2	
	17	Pw	3.85		3	Weevil	4.44		2		4.73		2		4.92		2	
	18	Pw	3.92		2		4.40		2		4.61		3		4.72		3	
	19	Pw	9.87		1	B	10.45		1		11.42		1		12.07		1	
	20	Pw	8.00		1		8.53		2		8.67		1		8.92		1	T
	21	Pr	11.27		1	B	12.30		1		13.00		1		12.72		1	

B - Banded T - Thinned D - Dead

SAPLING-DIAMETER RECORD

(FOR A SINGLE SUBTYPE AND A SINGLE AGE-CLASS)

FORM 4

UNIT P.S.P. 1. LOCALITY Petawawa

MEASUREMENTS BY T. Smith NOTES BY R. A. Thomsen DATE Aug. 12, 1918

PLOT No.	STRIP No.	W. Pine D. B. H. CLASS 1"	2"	3"	R. Pine D. B. H. CLASS 1"	2"	3"	D. B. H. CLASS 1"	2"	3"	D. B. H. CLASS 1"	2"	3"	D. B. H. CLASS 1"	2"	3"	D. B. H. CLASS 1"	2"	3"
	1		//	///															
	2		/	//															
	3			///															
	4		///	///		/													
	5		//	//			/												
	6		/	//															
	7		///	///			/												
	8			/															
	9		/	///															
	10		/	////			/												
	11		//	///															
	12		/	~~////~~															
	13		//	//															
TOTAL			19	36		1	3												
AVERAGE PER ACRE																			

Select a position about 100 feet from the tree to be measured, at a point from which the top may be seen. The top of almost any tree can be seen from some point, and at a proper distance from the base for height measurements. It will usually be possible to measure several trees from one point. The technique is to have someone jar the tree slightly with his hand, which will cause the tip to vibrate. Another man circles the tree with height-measuring instrument until he can see this tip vibrating. This method is, of course, best practised on calm days.

Record the number of some tree close to the measuring point, so that re-measurements may be taken if possible from approximately the same position (Column 3). Failing this, place a height picket at point of set-up. Measure the distance from the plumb-bob to the centre of the tree sighted in feet and tenths and record in Column 4. Take instrument readings. The instrument reading, from instrument to top of tree, should be recorded in Column 6. The reading from instrument to breast height should be entered in Column 7 (it is frequently impossible to see the base of the tree and therefore the breast height point has been selected). If the breast height point is below the level of the instrument, the reading will be minus; if above the level of instrument, the reading will be plus. In either case the sign must be recorded. Where reading is taken to the base of the tree, this fact should be noted in heading of Column 7.

To obtain the height:

(1) Add the minus value of Column 7 to, or subtract the plus value from, the value of Column 6;
(2) Multiply the resultant factor (a decimal value) by the distance, Column 4;
(3) Add the breast height elevation, 4·5 feet (when applicable);
(4) Record the result to the nearest foot in Column 9.

Heights of saplings may be recorded on the same form in the same manner, but the distance from the tree need not be as great as for larger trees. Because they are not numbered, there is no assurance that the same trees will be re-measured. However, the possibility of error in the smaller trees is less, and these errors may be cancelled out by measuring a large number of them. Use of an extension pole may be found more suitable for measuring trees up to 25 feet high, since heights are read directly (46).

Reproduction. Form 6.—It may be argued that there is little or no point in taking any reproduction records in stands that are even-aged and already well stocked, and that the occurrence of reproduction in such stands is an indication of some weakness in the method of treatment employed. Nevertheless, nature does create disturbances, and a record of the trend of reproduction is desirable even in these stands. Records of reproduction are very essential in all disturbed stands. Therefore, since the additional time and cost involved are comparatively small, the practice of establishing reproduction subplots on every permanent sample plot should be followed.

On each permanent sample plot of half an acre or more, five regularly distributed subplots, size 3·3 feet × 66·0 feet (1/200 acre), are to be established. The boundaries of each subplot should be clearly marked with a permanent picket at each corner, and the dimensions of each should be recorded.

The tally of the seedlings of each species should be recorded on Form 6. The seedlings should be divided into two groups—young (under 20 years) and likely to be thrifty, and old (over 20 years) and not likely to respond to treatment of the stand. Each group should be divided into three height classes (a) up to 0·5 foot (b) 0·5 to 3·0 feet, and (c) over 3·0 feet. The progressive change in numbers from one class to another provides a record of their development. When there are more than 100 seedlings per plot (20,000 per acre) of any one species in any class, a complete count is not required, merely record '100+'.

TREE-HEIGHT RECORD

FORM 5

Height in feet. Diameters in inches and tenths.

PERMANENT SAMPLE PLOT No. 1 LOCALITY Petawawa SHEET No. 1

ABNEY LEVEL WITH PER CENT ARC SET UP ON TRIPOD; TAPE OR CHAIN IN FEET TO BE USED.

	First measurement	Second measurement	Third measurement
Measured by	J. W. B. Sisam	T. Kearney	
Notes by	K. Burnett	Wyatt	
Date	Aug. 1933	Sept. 1938	
Computed by	K. Burnett	T. Kearney	
Date	Oct. 1933	Nov. 1938	

Tree No. 1	Species 2	From Tree or Picket No. 3	Distance 4 Feet	D. B. H. 5 Inches	Instrument Reading To Top 6 Factor	Instrument Reading To B. H. 7 Factor	Total Height 8 Feet	From Tree or Picket No. 3	Distance 4 Feet	D. B. H. 5 Inches	Instrument Reading To Top 6 Factor	Instrument Reading To B. H. 7 Factor	Total Height 8 Feet	From Tree or Picket No. 3	Distance 4 Feet	D. B. H. 5 Inches	Instrument Reading To Top 6 Factor	Instrument Reading To B. H. 7 Factor	Total Height 8 Feet
1	Pw								85	8.07	62	-5	61						
2	Pw	21	42	9.92	114	-29	60												
3	Pw																		
4	Pw	21	40	10.46	135	-30	66		66	11.18	82	-18	70						
5	Pw																		
6	Pw																		
7	Pw								81	12.20	80	0	69						
8	Pr								77	14.26	83	-9	75						
9	Pw	22	40	5.83	82	-30	45												
10	Pr								57	13.98	95	-17	68						
11	Pw	24	30	5.11	120	-33	46												
12	Pw																		
13	Pw																		
14	Pw																		
15	Pw																		
16	Pw								65	7.09	78	-9	61						
17	Pw	24	34	4.92	118	-26	49		44	5.11	98	0	48						
18	Pw	24	26	4.72	107	-34	37		54	4.81	68	0	41						
19	Pw	61	42	12.07	124	-31	65		74	12.68	96	+5	72						

DISTANCE—This is the distance from the instrument to the tree measured, to be recorded in feet, to nearest foot

INSTRUMENT READING TO B. H.—If B. H. is below instrument level the value will be minus. If above instrument level it will be plus. In either case the sign must be recorded.

TO OBTAIN HEIGHT—(1) Add the minus value, or subtract the plus value of column 7 to or from the value of column 6. (2) Multiply the resultant factor (a decimal value) by the distance, column 4. (3) Add the breast-high elevation, 4.5 feet. (4) Record the result to the nearest foot in column 8.

NOTE—Measurements in Col. 7 (1933) were to base of tree, not to B.H.

FORM 6

SUMMARY OF SEEDLING TALLY SHEETS

5 plots 3.3'x66'
Area 1/40 acre.

(FOR A SINGLE SUBTYPE AND A SINGLE MAIN-STAND AGE-CLASS)

PERMANENT SAMPLE PLOT No. 1 SUBTYPE Pw Pr. AGE-CLASS 60 years

COMPILED BY T. Kearney DATE Oct. 12, 1938 CHECKED BY R. Smith DATE Oct. 15, 1938

SPECIES W. Pine — NUMBER OF SEEDLINGS ON PLOT

PLOT No.	Young (up to 20 yrs.) A (Up to 0.5 ft.)	Young B (0.5 to 3 ft.)	Young C (Over 3 ft.)	Old (over 20 yrs.) A (Up to 0.5 ft.)	Old B (0.5 to 3 ft.)	Old C (Over 3 ft.)
A	17					
B	42					
C	37	1				
D	31	4				
E	18					
TOTAL	145	5				
PER ACRE	5800	200				
SUB-TOTAL						
GRAND TOTAL	6000					

SPECIES W. Spruce — NUMBER OF SEEDLINGS ON PLOT

PLOT No.	Young (up to 20 yrs.) A (Up to 0.5 ft.)	Young B (0.5 to 3 ft.)	Young C (Over 3 ft.)	Old (over 20 yrs.) A (Up to 0.5 ft.)	Old B (0.5 to 3 ft.)	Old C (Over 3 ft.)
A	12					
B	4					
C	3					
D	2					
E	1					
TOTAL	22					
PER ACRE	880					
SUB-TOTAL						
GRAND TOTAL	880					

SPECIES Balsam Fir — NUMBER OF SEEDLINGS ON PLOT

PLOT No.	Young (up to 20 yrs.) A (Up to 0.5 ft.)	Young B (0.5 to 3 ft.)	Young C (Over 3 ft.)	Old (over 20 yrs.) A (Up to 0.5 ft.)	Old B (0.5 to 3 ft.)	Old C (Over 3 ft.)
A	23	1				
B	38	1	1			
C	22	1	1			
D	10					
E	10	1				
TOTAL	103	4	2			
PER ACRE	4120	160	80			
SUB-TOTAL						
GRAND TOTAL	4360					

SPECIES S. Maple — NUMBER OF SEEDLINGS ON PLOT

PLOT No.	Young (up to 20 yrs.) A (Up to 0.5 ft.)	Young B (0.5 to 3 ft.)	Young C (Over 3 ft.)	Old (over 20 yrs.) A (Up to 0.5 ft.)	Old B (0.5 to 3 ft.)	Old C (Over 3 ft.)
A		1	1			
B		3				
C	1					
D	2	3	1			
E		2	1			
TOTAL	3	9	3			
PER ACRE	120	360	120			
SUB-TOTAL						
GRAND TOTAL	600					

FORM 7

FOREST DESCRIPTION

PERMANENT SAMPLE PLOT No. 1 LOCALITY Petawawa
NOTES BY R. Smith DATE June 1918

Cover Type Before Treatment FwPr:- Pw 57%, Pr. 31%, BwA 11% Density 289 S.D.I. Site Type Ma-Cor.
After Treatment FwPr.- Pw. 59% Pr. 38% BwA 3% 215 S.D.I.

Slope (in percentage) 7 per cent Aspect North Altitude 525 feet

Topography and Situation Sheltered, regular slope draining to Corry Lake

SOIL PROFILE:—

Litter 1"-2" Raw Humus 0.5" Humus 0.5"-1.5" Leached Soil 3"

Unleached Soil 3" Sub-soil Sand-rock Moisture Dry Surface Rock (percentage of total area) Nil

Ground-cover* Maianthemum - Moderate - main part
Cornus Scattered - widely represented
Ferns - Scattered - widely represented
Gaultheria - scattered - single specimens

Underbrush* Corylus - Moderate - main part
Sweet fern - Scattered - single specimens

Small Growth* Balsam Fir - widely represented
Aspen - widely represented
Spruce - single specimens

*State whether "complete", "thick", "moderate", "scattered", or "none"; record main species only and state whether species comprise "main part" of ground-cover (underbrush or small growth), are "widely represented" or occur in "single specimens". (See notes in Forest Research Manual.)

FORM 8

HISTORY AND PRESENT CONDITION OF STAND

PERMANENT SAMPLE PLOT No. 1 LOCALITY Petawawa
NOTES BY R. Smith DATE June 1918

Age - 40 years Origin Following logging and fire about 1875

Fires (since stand originated) None

Logging None Amount of unrotted slash (in percentage of total area) None

Abnormal windfall None

Insect attacks Continuous weevil damage

Fungus attacks None

ANALYSIS OF STUDY

Study-classification No.
III B(b) Project 1. Thinning PwPr subtype on Ma-Cor. site type
II B(a) Project 2. Site upon growth and yield.
II B(a) Project 3. Site upon reproduction.
II F(a) Project 4. Density upon reproduction.

Object of establishment Study effect of selection thinning on growth, yield, and reproduction

Methods selected to carry study to completion One of a series of P.S.Ps. moderately thinned; best trees selected for final crop

Results to be expected, and within what period - Improvement in increment and quality - within 20-30 years when Pr will be approching maturity, and reproduction cutting may be made.

Application of results obtained, present and future Information may be applied to large scale intermediate cutting operations.

Provision for extension of the study - Remeasurements to be made at 5 year intervals; Additional plots to be established from time to time.

Descriptive Data.—"Anyone who establishes a permanent sample plot should recognize that he thereby assumes responsibility for furnishing future workers with a complete picture of conditions on the plot at the time of its establishment. Not only must each plot be properly marked and all measurements be in perfect order, but all notes and records must be full and complete. Otherwise, the plots may fail to yield the desired results and those who in later years become responsible for their care and for analysis of the data may be led into serious mistakes" (49: p. 7).

Forms 7 and 8 have been devised for records of data essential for most sample plots. Specific additional descriptive information that, in the opinion of the investigator, may seem necessary or desirable for certain plots should be added. In so far as observations and field data will permit, these forms should be completed in the field at the time the plot is established. Some information is dependent upon preliminary compilation of field records. This phase too should be completed before the records are filed away.

Cover Type.—The cover type, or, better, cover subtype, as found from the percentage distribution of the basal area of the species, should be recorded both before and after treatment. The predominant species determine the name of the cover type in accordance with the standard legend. The two records will illustrate any change in cover type produced by the treatment.

Site Type.—The vegetation site type classification should be used, where one has been approved for the area. Failing this, a site classification based on the age-height of dominant trees in at least three site classes must be used. This information should be inserted by the compiler.

Density.—The stand density index (S.D.I.) is to be calculated and inserted by the compiler (page 54).

Species in Per Cent.—The percentage of the total basal area represented by each species is to be calculated by the compiler and inserted.

Slope.—The slope should be recorded in percentage.

Aspect.—The direction towards which the slope falls.

Altitude.—The elevation above sea-level. This need only be an approximation.

Topography and Situation.—A general description of the contours, and the situation in relation to surrounding area.

Soil Profile.—One or more soil pits 2 to 3 feet deep should be dug, and the average depth of each of the various soil layers should be recorded in inches, or in feet and tenths of feet.

Moisture.—Dry (little or no trace of moisture): moist (when water drips from a piece squeezed in the hand): wet (when water drips from a piece held in the hand without pressure).

Ground Cover, Underbrush, Small Growth.—These are generally recorded for one of the following purposes:—

1. To identify the site type.
2. To evaluate the effect of density upon reproduction of desirable tree species.
3. To prepare a site-type classification.

For purposes (1) and (2) a general ocular estimate of occurrence and distribution of the plant species involved seems sufficient. Merely record the main species, and state whether the coverage is complete, thick, moderate, or scattered. For the third purpose, however, a complete record of the vegetation found on well-distributed Raunkiaer ring or quadrat plots should be made.

For ground cover records, botanical nomenclature should be used. Either common or botanical names may be used for records of underbrush and small growth.

Photo. 3.—Characteristic vegetation of the Oxalis-Cornus site type, favourable to the balsam-spruce cover type. (Photo. No. 23292).

Photo. 4.—Cornus-Maianthemum site-type vegetation, adapted to growth of white and red pine. (Photo. No. 23040).

PHOTO. 5.—White and red pine on Maianthemum-Corylus site type. Trees blazed marked for moderate second thinning. Note large but defective white pine marked for removal in left foreground. (Photo. No. 21197).

Age.—In general it can readily be determined whether a stand is even-aged, two-aged, or uneven-aged, by observation of the crown and diameter classes. In an even-aged stand the average age, as determined from borings at stump height on ten dominant trees, plus the years required to reach stump height, should suffice to determine the age within five years. This may be checked by an examination of fire scars, if any are to be found.

Where the stand is distinctly two-storied and therefore probably two-aged, increment borings in ten dominant trees of each story should provide the required information. In recording the two age classes the range of diameters and, if possible, the dominant species in each class should be given. For uneven-aged stands the ages representing the major portion of the stand should be determined.

Origin.—Unless authentic historical information concerning the nature and date of disturbances which resulted in the present upper-story stand is available, an attempt should be made to ascertain the age or ages by examination of fire scars, stumps, or windfalls on the area. Seldom will virgin stands be found, except in black spruce swamp or tolerant hardwood forest types. Other stands, mature or approaching maturity, have probably resulted from fire, the date of which may be found from scars on occasional veteran trees that survived. Younger stands may have resulted from logging (or logging and fire), severe windstorms, insect infestation, or fungous attack.

Fires.—Not infrequently second or third stories in the stand are the result of subsequent fires. The dates of these can usually be fixed from scars on the upper-story trees.

Logging.—Unless historical records are available, it is more difficult to determine the date of logging disturbances. However, an examination of second growth found near old stumps, trails, or skidways may furnish the clue.

Insect and Fungus Attacks—Information on the health of the stand, past and present, should be recorded. Unfavourable conditions should be referred to the entomologist or pathologist for consideration.

Photo. 6.—Stand in Photo. 5 immediately after thinning. (Photo. No. 21344).

Photo. 7. Stand shown in Photos. 5 and 6 after ten years. Corylus has taken advantage of increased light. Marked tree at right was 9·4″ d.b.h. in 1932 (Photo. 6) and 10·5″ in 1942 (Photo. 7). Banded trees selected as probable final crop. (Photo. No. 26489).

Analysis of Study.—A description of the project, including classification, descriptive title and number, purpose, methods to be followed, and results to be expected should be given here.

Photographs.—No amount of text can describe the development of a stand as clearly as a series of good photographs of a section of a plot taken before and after treatment, and at periodic intervals. The lens should be good, the size of photograph should not be less than 4 inches × 6 inches. The camera should be set firmly in position, by tripod or otherwise. The length of exposure should be determined by a reliable exposure meter; the electric cell photometer is recommended. For detail in the foreground only, a large stop, with short exposure, should be used. For general detail use a small stop and correspondingly long exposure.

It is important that the field of the photograph be identical in every photograph in a series, if the maximum comparison value is to be obtained. A slight deviation in the set-up will result in photographs that cannot be properly compared with the original. Therefore the camera point should be marked by a photograph picket or other identification mark. The field of the photograph should also be identified by some permanent object, for instance, a certain easily identified tree at the right or left margin of the foreground. This tree should be designated by a piece of paper, a number card, or other object, at its base: the object selected should be unobtrusive, but clearly visible in ground glass or view finder. A card of standard size, say 4 × 6 inches, bearing a number, is helpful as an indication of scale. Good forest photographs cannot be taken in bright sunshine, because of the strong contrasts between sunshine and shade.

Full records of every photograph should be kept. These should include date and time of day, light conditions, exposure time and stop, and type of film. The title should be full, drawing attention to particular features to be noted. Each photograph should have its own full title. *Such titles as "same as last" should never be used.* If possible, the identification numbers of previous photographs in the series should be recorded. The records should be signed by the photographer.

Good aerial photographs of areas including sample plots are frequently obtainable. Prints of the section containing the sample plot and its surround, enlarged to a uniform scale of approximately 100 feet to the inch, should be obtained. It should, however, be borne in mind that photographs taken from a very high altitude may not reveal the necessary detail when enlarged to the required scale. Determination of the exact location of the plots will call for detailed scrutiny and survey, unless identification marks are to be found on or near them.

Diary.—As soon as a plot has been established, brief diary notes recording the progress in establishing it should be made. Such a record may be of great value in re-examination work.

Remeasurement.—The proper interval between remeasurements depends to some extent upon the nature of the project. In intensive studies of seeding or reproduction it may be desirable to examine the plots annually during the term of the normal reproduction period, and thereafter at intervals of five years. For most other investigations an interval of five years is desirable, though the period may be lengthened to ten years in exceptional circumstances.

An attempt should be made to arrange for remeasurement of all plots in a single project at the time of year at which such plots were established. Thus the whole may be analysed together, without introducing the factor of seasonal variations.

(*a*) Examine corner posts and boundaries. If posts have been disturbed, reset; if defective, renew.

(*b*) Re-lay the strings to bound the 20-foot strips.

(*c*) Remeasure the diameters of all tagged trees, including dead ones, on the original Form 3. Check the measurements against the original records. Refer to the tree location map to find missing trees. Record any change of condition of trees, e.g., "Dead", in remarks column.
(*d*) Replace any missing tags.
(*e*) Tag any new trees that have entered the pole class from the untagged sapling class, record measurements on Form 3 and note in remarks "Near Tree No. . . . . .", and map their location.
(*f*) Tally all saplings on Form 4.
(*g*) Tally, separately, all unblazed dead saplings, and blaze them at once so that they will not be included in subsequent tallies.
(*h*) Remeasure heights of all trees previously measured.
(*i*) Count, classify, and record seedlings on the reproduction subplots.
(*j*) Make necessary diary notes.
(*k*) Prepare a remeasurement report covering all plots remeasured during the season.

Abandonment of Plots.—No plot should be abandoned without full assurance that it can no longer provide useful information. Although it may have served its original purpose, or by reason of disturbance or other cause may no longer serve the purpose for which it was first intended, it may continue to provide useful information on some other research problem. Apart from the cost of establishing it, the enhanced value as a result of the passing of time must also be weighed. All possibilities of salvage by conversion to some other project should be considered before actual abandonment. "When the value of a plot is in question, it may be advisable to continue plot measurements on a reduced scale only. . . . . . With such handling many plots, abandonment of which is considered, can be continued, possibly to surprise the investigator in later years with their value." (49, p. 61).

Compilation

There are many ways in which sample plot data may be compiled, many of them probably equally sound. But unless some standard method is followed by all investigators in one organization it is improbable that the material prepared for analysis will be either properly or readily comparable. Furthermore, experience has shown that, unless procedure is outlined in detail, omissions invariably result, and may not be discovered until it is too late or too costly to remedy them.

The first purpose of compilation is to obtain accurate, detailed stand tables, computed to an acre basis, all prepared from the same units of measure. The difference between the stand tables of two periodic measurements represents the development of the stand during the interval. It is more important, therefore, that the same method and units of measurement be used at each remeasurement than that the methods and units be entirely accurate.

A balance should also be maintained between the degree of precision in gathering data, and making compilations from them: a high degree of precision in compiling from rough data is obviously absurd.

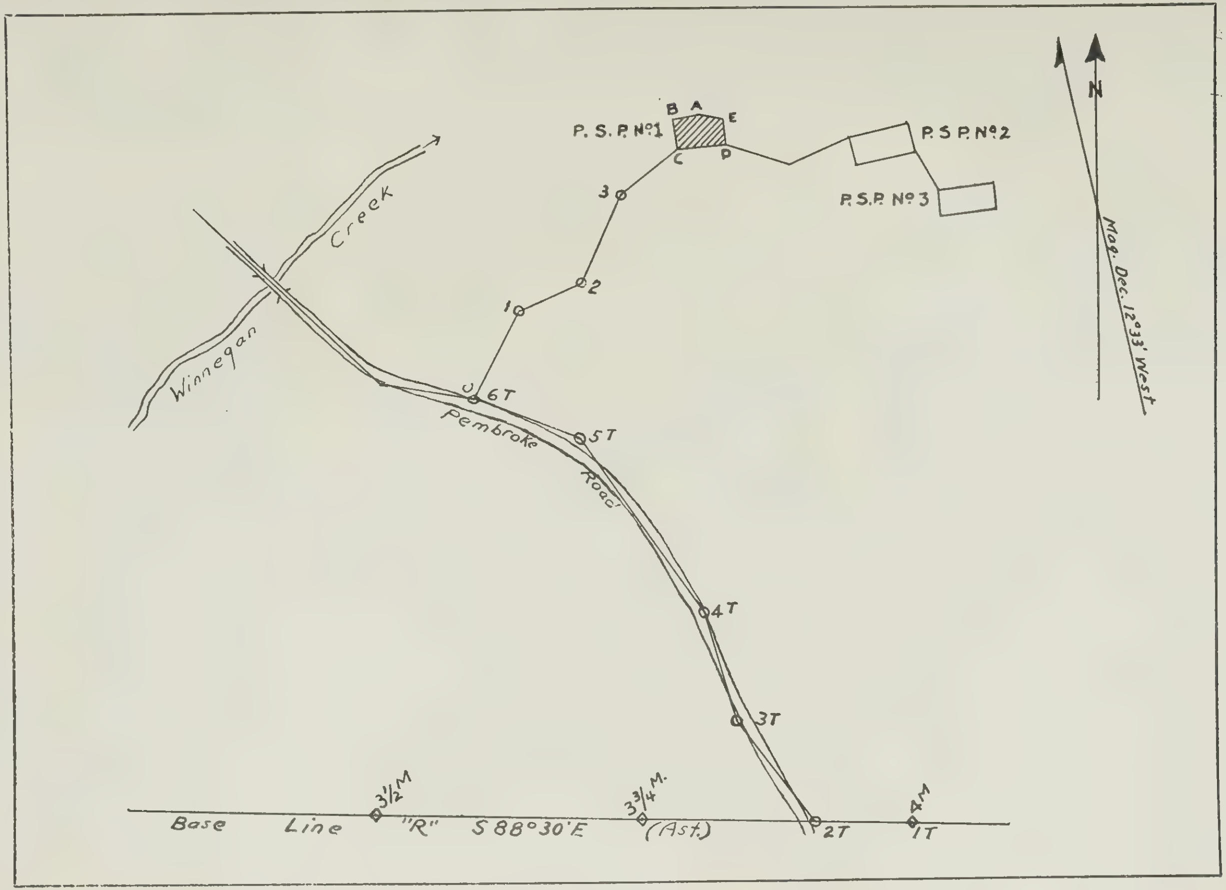
Filing Records.—Records are readily divisible into two classes, active records, constantly required and referred to, and compilation records—materials which have served their main purpose as soon as the results have been entered in the active records. Compilation records should, however, be retained for review or check, if necessary.

Of the active records, the stand tables and other compiled data are retained in the office, while survey notes and measurements of diameters and heights must be taken into the field for each remeasurement.

INDEX MAP

FORM 2

LOCALITY ....*Petawawa*.......... SHOWING LOCATION OF P.S.P. Nos. *1, 2, 3*...... SCALE........*10 chs.*.....=1 INCH



FORM 9

Ave. Diam. 6.7"
S.D.I. 215
S.I.I. 37

STAND TABLE FOR YEAR 1918 - After thinning
(AVERAGE FOR PLOT AND PER ACRE)

PERMANENT SAMPLE-PLOT No. 1 LOCALITY Petawawa AREA 0.84 Acre

COMPILED BY T. J. Kearney DATE March 1940 CHECKED BY R. H. Candy DATE April 1940

SPECIES	HEIGHT CURVES	VOLUME TABLES
W. Pine	P.S.P. 1 1918	F.C. 65. Nos. 5-35
R. Pine	P.S.P. 1 1918	F.C. 70. " 11-41
W. Spruce	Actual Ht. 1918	F.C. 70. " 2-32
Balsam Fir	Actual Ht. 1918	F.C. 65. " 7-37
W. Birch	Actual Ht. 1918	— " 13-43

DIAM. CLASS	White Pine					Red Pine					White Spruce					Totals					Totals per acre				
	AV'GE D.B.H.	NUMBER OF TREES	BASAL AREA	TOTAL VOLUME	MERCH. VOLUME	AV'GE D.B.H.	NUMBER OF TREES	BASAL AREA	TOTAL VOLUME	MERCH. VOLUME	AV'GE D.B.H.	NUMBER OF TREES	BASAL AREA	TOTAL VOLUME	MERCH. VOLUME	AV'GE D.B.H.	NUMBER OF TREES	BASAL AREA	TOTAL VOLUME	MERCH. VOLUME	AV'GE D.B.H.	NUMBER OF TREES	BASAL AREA	TOTAL VOLUME	MERCH. VOLUME
Inches	Inches		Sq. ft.	Cu. ft.	Cu. ft.	Inches		Sq. ft.	Cu. ft.	Cu. ft.	Inches		Sq. ft.	Cu. ft.	Cu. ft.	Inches		Sq. ft.	Cu. ft.	Cu. ft.	Inches		Sq. ft.	Cu. ft.	Cu. ft.
1																									
2		19	0.42	5.5													22	0.49	6.3			26	0.58	7.5	
3		36	1.76	28.4													42	2.08	33.4			50	2.48	40.1	
TOTAL		55	2.18	33.9													64	2.57	39.7						
PER ACRE		66	2.59	40.7													76	3.06	47.6			76	3.06	47.6	
4	4.1	33	3.04	49.5	8.6												41	3.75	62.3	13.0		49	4.50	74.8	15.6
5	5.0	38	5.17	89.7	45.6												51	7.11	130.7	66.2		61	8.53	156.8	79.4
6	6.0	36	7.06	129.2	90.0												42	8.21	154.1	108.5		50	9.85	184.9	130.2
7	7.0	30	8.01	154.8	120.0												34	9.10	180.2	140.7		41	10.92	216.2	168.8
8	8.0	26	9.07	182.0	150.8												39	13.57	286.6	238.3		47	16.29	343.9	286.0
9	9.0	14	6.19	126.0	110.6												26	11.37	246.0	212.6		32	13.64	295.2	251.1
TOTAL		177	38.54	731.2	525.6												233	53.11	1059.9	779.3		280	63.73	1271.8	935.1
PER ACRE		212	46.25	877.4	630.7												280	63.73	1271.8	935.1					
10	10.0	10	5.45	113.0	100.0												19	10.55	232.7	207.1		22	12.66	279.3	248.5
11	10.9	7	4.54	98.0	84.7												19	12.46	292.4	253.9		23	14.95	350.9	304.7
12	11.8	2	1.52	34.8	30.8												6	4.61	111.6	98.4		8	5.53	133.8	118.1
13																									
14	.2	1	1.10	25.0	22.4												1	1.10	25.0	22.4		1	1.32	30.0	26.9
15																									
16																									
TOTAL		20	12.61	270.8	237.9												45	28.72	661.7	581.8					
PER ACRE		24	15.13	324.9	285.5												54	34.46	794.0	698.2		54	34.46	794.0	698.2
GRAND TOTAL		252	53.33	1035.9	763.5												342	84.40	1761.3	1361.1					
PER ACRE		302	63.46	1243.0	916.2												410	100.43	2113.4	1633.3		410	100.43	2113.4	1633.3

For these reasons it is impractical to bind all notes, even of a single plot, in a single loose-leaf binder. It is inconvenient, too, to have notes of active material for more than one plot in a single binder. Two investigators may require the notes in one binder at the same time, or an investigator may require notes for a number of plots which are bound in separate, unwieldly binders. The tendency then is to extract the notes required, and confusion is only too likely to result either from notes being not returned intact or returned to the wrong place. A more satisfactory system is to keep records in filing pockets or holders, using two pockets for the records of each plot, the one for active, the other for compilation records. These should then be filed in numerical order. It is then a simple matter to draw the complete records for any plot or plots, and to keep them in their proper place.

Records taken into the field should be charged out to the investigator responsible, so that their whereabouts may always be known.

Mapping.—An index map, Form 2, showing the location and shape of the plot in relation to the tie point and base line, and to other plots tied to it, should be prepared from the field sketch map and survey records. It is desirable also to have the position of the plots indicated on the cover-type or improvement map of the station or area.

The tree location map sketched in the field should be drafted on a scale of 10 feet per inch. The top of the map should always be towards the north. The diameter of trees should be indicated on a scale of 1/40 inch per inch. The lines dividing the 20-foot tally strips should be shown. The position of reproduction plots should be drafted. The position of witness trees, and photo posts, if any, should be indicated. For saplings, for which individual measurements are not recorded, a dot, accompanied by its species symbol, will suffice.

Stand Tables Required, Form 9. Separate stand tables should be prepared to show (1) the living stand before treatment, (2) trees removed in treatment, (3) trees remaining after treatment, and (4) the final crop trees at time of establishment, and at each remeasurement. A mortality table must be prepared for each remeasurement date.

Each stand table should show the number of trees, basal area, and total volume by species and diameter classes. Merchantable volume to some utilization requirement, and volume of defective trees, may possibly be required in some instances. The average diameter, average height, stand density index, and stock intensity index should also be shown.

Each of these tables involves a large amount of compiling before the data can be entered in the table (Form 9). The procedure has been standardized as follows:

(1) *Summary of Number of Trees, Form 10.*

It is important to be sure that all trees on the plot, tagged and untagged, are accounted for at every remeasurement. This check should cover living trees, including new trees entering the stand, and trees that have died or been removed since the previous measurement. A single large tree omitted or duplicated may seriously affect the final results. In the cumulative summary, Form 10, the past stand, less trees that have died or been removed, plus new trees that have entered the stand during the interval, must check with the number of trees found by actual count in the present stand. Any discrepancy must be located and accounted for before the compilation proceeds.

(2) *Summary of Diameters, Form 11.*

The next stage is to separate all trees by diameter classes and species, by transfer from the field records, Forms 3 and 4, to Summary Form 11. For example, all trees from 3·51 inches to 4·50 inches inclusive must be listed in the 4-inch class. When this summary is completed, the total number of all diameter classes must check with the total number of trees on the plot, as shown on the "Summary of Number of Trees", Form 10.

FORM 10

CUMULATIVE SUMMARY OF NUMBER OF TREES

Permanent Sample Plot No. 1

—	Untagged	Tagged	Total
1918—Before thinning	64	455	519
Thinned		177	177
After thinning	64	278	342
1923—Dead			10
Living	38	294	332
1928—Dead			6
Living	28	298	326
1933—Dead			21
Before thinning	18	287	305
Thinned	4	105	109
After thinning	14	182	196
1938—Dead			9
			187
New Trees			37
Living	44	180	224
1941—Dead			7
			217
New Trees			11
Before thinning	53	175	228
Thinned	20	89	109
After thinning	33	86	119

SUMMARY OF DIAMETERS

FORM II

P. S. P. No. 1 SPECIES White Pine LOCALITY Petawawa

COMPILED BY R. Johnson CHECKED BY T. Black DATE Oct. 12 1918

DIAMETER-CLASS	4–INCH			5–INCH			6–INCH			7–INCH			8–INCH			9–INCH			10–INCH		
ENTRY No.	TREE No.	D. B. H. (INCHES)	Crown	TREE No.	D. B. H. (INCHES)	Crown	TREE No.	D. B. H. (INCHES)	Crown	TREE No.	D. B. H. (INCHES)	Crown	TREE No.	D. B. H. (INCHES)	Crown	TREE No.	D. B. H. (INCHES)	Crown	TREE No.	D. B. H. (INCHES)	Crown
1	12	4.47	2	3	5.15	1	1	5.90	1	2	7.50	1	4	8.10	1				19	9.87	1
2	13	3.73	3	5	4.60	3	6	6.45	1				7	8.46	1						
3	15	4.41	3	9	5.00	2							20	8.00	1						
4	17	3.85	3	11	4.59	2															
5	18	3.92	2	14	4.74	2															
6				16	4.92	2															
7																					
8																					
9																					
10																					
11																					
12																					
22																					
23																					
24																					
TOTAL	33	13[illegible].30		38	190.00		36	215.28		30	211.50		26	208.78		14	128.10		10	99.80	
AVERAGE		4.10			5.00			5.98			7.05			8.03			9.15			9.98	

FORM 12

SUMMARY OF HEIGHTS

P.S.P. No. 1 SPECIES White Pine LOCALITY Petawawa

COMPILED BY B. Koepke CHECKED BY J. W. B. Sisam DATE Oct. 4. 1933

DIAMETER-CLASS	3-INCH			4-INCH			5-INCH			6-INCH			7-INCH			8-INCH		
ENTRY NO.	TREE No	D.B.H. (INCHES)	HEIGHT (FEET)	TREE No.	D.B.H. (INCHES)	HEIGHT (FEET)	TREE No.	D.B.H. (INCHES)	HEIGHT (FEET)	TREE No.	D.B.H. (INCHES)	HEIGHT (FEET)	TREE No.	D.B.H. (INCHES)	HEIGHT (FEET)	TREE No	D.B.H. (INCHES)	HEIGHT (FEET)
1	30	3.15	30	25	4.42	45	12	5.11	45	9	5.83	44	180	7.30	55	190	8.20	61
2	193	3.08	29	26	4.43	50	17	4.92	48	167	5.82	34	182	6.78	52	246	8.44	55
3	339	3.05	35	186	3.65	37	18	4.72	36	204	5.51	41	187	6.97	54	236	8.11	55
4				194	3.79	35	65	4.96	43	254	5.88	52	191	6.97	51	281	8.13	54
5				205	4.39	35	110	4.64	36	277	6.03	39	251	6.97	57	318	8.37	55
6				263	4.10	35	133	4.74	41	301	6.25	52	261	7.10	58	322	7.79	56
7				285	3.91	31	164	5.18	49	324	6.00	54	330	7.47	54	323	7.56	61
8				288	4.37	46	166	5.12	41				331	6.65	57	328	7.72	57
9				325	3.88	43	326	5.39	47							332	7.84	63
10																		
11																		
12																		
13																		
23																		
24																		
TOTALS	3	9.28	94	9	36.94	357	9	44.78	386	7	41.32	316	8	56.21	438	9	72.16	517.
AVERAGE		3.1	31		4.1	40		5.0	43		5.9	45		7.0	55		8.0	57

When the number of trees has thus been determined, the average diameter in each class should be calculated. The average diameter of saplings, untagged, will necessarily be recorded as of the integral inch class. The number of trees and average diameter should then be transferred to the proper columns in the stand table, Form 9.

(3) *Basal Areas.*

The basal areas should next be computed and entered in Column 4, Form 9.

(4) *Diameter-Height Curves.*

Diameter-height curves must be prepared before volumes can be computed.

(a) Check the height calculations recorded on Form 4.

(b) Sort the diameter-height records by species and diameter classes on Form 12.

(c) Compute the average diameter and height for each class.

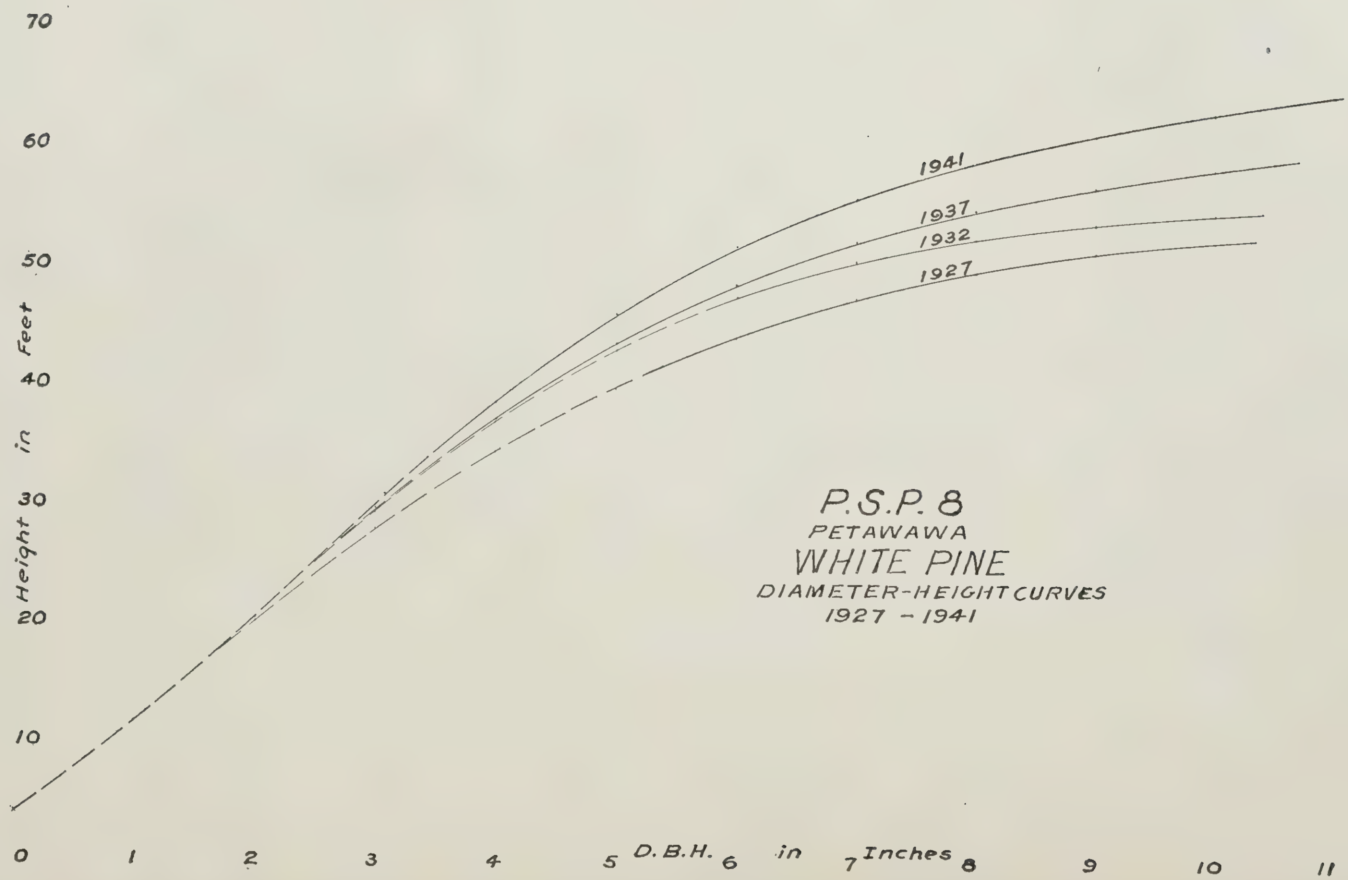
(d) Prepare diameter-height curves for each species on Form 13, plotting height over diameter on scales of 1 inch per inch, and 10 feet per inch. Since diameters are measured at breast height the point of origin for height is 4·5 feet on the height scale.

It is highly desirable that the curves for every period, for each species, be shown on a single graph. This method of comparing curves is an aid in adjusting the position of the curves where data are lacking or appear to be somewhat inadequate. Furthermore it presents a picture of the changes that occur in the relationship between diameter and height which may have resulted from the treatment to which the stand has been subjected.

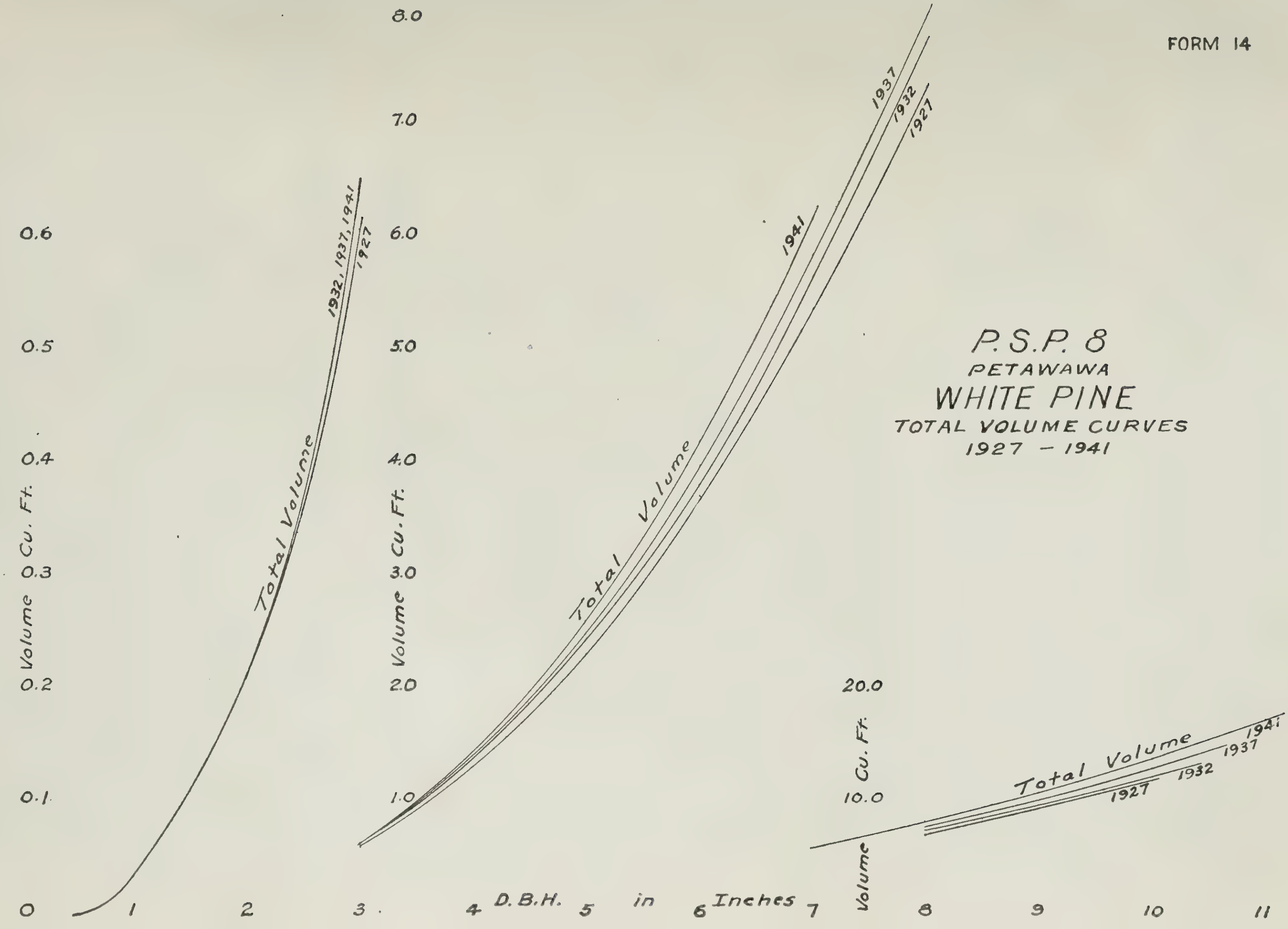
(5) *Volume Curves.*

Whatever volume tables are selected for preparation of the original stand tables should be used throughout the life of the plot, and therefore the designation of the tables selected should be recorded on the stand table. However, when the trees have entered a new form class during any interval the new form-class tables should be used. The change of tables should be recorded.

FORM 13


P.S.P. 8
PETAWAWA
WHITE PINE
DIAMETER-HEIGHT CURVES
1927 - 1941
1941
1937
1932
1927
Height in Feet
70
60
50
40
30
20
10
D.B.H. in Inches
0
1
2
3
4
5
6
7
8
9
10
11

FORM 14


P.S.P. 8
PETAWAWA
WHITE PINE
TOTAL VOLUME CURVES
1927 – 1941
Volume Cu. Ft.
0.1
0.2
0.3
0.4
0.5
0.6
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
10.0
20.0
Total Volume
1932, 1937, 1941
1927
1937
1932
1941
D.B.H. in Inches
0
1
2
3
4
5
6
7
8
9
10
11

Since values on most volume tables are given for even-inch diameter classes, and 10-foot height classes it is necessary to prepare volume curves (volume over diameter), to simplify interpolation. From these curves values for fractional inches in diameter and corresponding height may be read. Form 14 shows the method of construction of these diameter-volume curves.

As with diameter-height, successive curves should be shown on the same graph for readier comparison.

(6) *Volumes.*

The volumes for each diameter class should now be calculated, obtaining the unit volume from the volume curve and multiplying by the number of trees in each diameter class. The results should be entered in Columns 5 and 6, Form 9. Often species of minor importance and of infrequent occurrence may be combined and recorded as "other species". The number of trees, basal area, and volume should be computed to an acre basis; saplings, poles, and standards should be dealt with separately, as provided for in Form 9.

(7) *Supplementary Information.*

Average Diameter—Divide total basal area of all species by number of trees to obtain average basal area; read the corresponding diameter from basal area tables; record on Form 9.

Form 15

CROWN CLASS DISTRIBUTION

P.S.P. 51—Petawawa

Crown Class:

(In per cent of total number of living trees)

Date	1 (Dominant)	2 (Intermediate)	3 (Suppressed)	Total
1921—Before thinning—191 living trees				
Saplings	....	22·0	17·2	39·2
Poles	17·2	33·0	5·2	55·4
Standards	4·9	0·5	....	5·4
Total	22·1	55·5	22·4	100·0

Average Height—Read height for the average diameter from the diameter height curve for the predominant species, for the year concerned; record on Form 9.

Stand Density Index—Read the stand density unit for the average diameter from Stand Density Unit Table and multiply by the total number of trees; record on Form 9.

Stock Intensity Index—Divide total volume by average height; record result, to one decimal place, on Form 9.

Reproduction. Form 6.—In the case of the reproduction stands, the only compilation necessary is to total the number of seedlings for each species and height class on all the subplots and compute the total per acre. Care must be taken to make the computation per acre on the basis of the total number of plots, whether seedlings are found on every plot or not. The computed values may be shown on the field tally sheet, Form 6, and the field form then becomes part of the compiled stand records.

Crown-Class Distribution. Form 15.—It is desirable to know what proportion of the several crown classes of the various species are represented in the pole, standard, and veteran classes respectively. It is important to learn what changes

Form 16

DIAMETER GROWTH

PSP 9, Petawawa. Period 1928–1938

Compiled by Sangster, June, 1938.

Species	Diameter Class											
	Four-inch			Five-inch			Six-inch			Seven-inch		
	Tree No.	Diameters		Tree No.	Diameters		Tree No.	Diameters		Tree No.	Diameters	
		1928	1938		1928	1938		1928	1938		1928	1938
	1	2	3	1	2	3	1	2	3	1	2	3
Red Pine...	97	3·90	3·91	4	5·42	5·42	9	6·21	6·33	8	7·23	7·73
	140	4·30	4·30	35	5·30	5·30	13	5·83	5·87	16	7·37	7·57
				48	4·81	4·81	25	6·07	6·15	22	6·63	6·77
				118	4·50	4·50	45	5·80	5·85	32	6·66	6·73
							62	5·77	6·09	36	6·97	7·20
							75	5·85	5·91	38	6·93	7·11
							92	6·01	6·14	87	7·15	7·49
							115	5·90	6·22	91	7·09	7·93
										100	7·09	7·81
										101	7·43	8·00
Total....	21	8·20	8·21	4	20·03	20·03	8	47·44	48·56	10	70·55	74·34
Average..		4·10	4·10		5·00	5·00		5·93	6·07		7·05	7·43

occur in these proportions and therefrom to learn the trend of development during each period; and what effect treatment has had in bringing about better distribution.

Information as to the most desirable crown-class distribution for various cover types and age classes is still lacking, and it is only by detailed study of existing distribution that a suitable unit of measure can be evolved. This information can only be obtained from permanent sample plot records. Such a unit of measure will probably be a valuable supplement to stand density measurements in determining desirable stand improvement treatment.

(*a*) From the diameter records, Form 3, make a dot tally of the tree or crown classes, separating each crown class into three size classes: poles, standards, and veterans.

(*b*) Compute the percentage proportion of each subdivision on the basis of the total number of trees tallied.

(*c*) Tabulate the results, and attach the table, Form 15, to the stand table records.

Diameter and Height Growth.—It is not sufficient to know the development of the stand as a whole, as given by the stand tables. The periodic changes in diameter and in height growth for each diameter class should be investigated. Such information is necessary to learn in which classes profitable growth rate is occurring, when release occurs, when growth rate declines, when thinnings should be from below or from above, the relationship between mortality and diameter classes, and the relationship between diameter and height growth in each diameter class. Relationship between density, crown class, and diameter class should also be observed.

(*a*) Prepare Form 16. From the summary of diameters (Form 11) for the measurements at the beginning of the period, list the tree numbers in each diameter class in Column 1, Form 16.

(*b*) From the diameter records (Form 3) record the diameters at the beginning and end of the period of those trees remaining in the stand at the end of the period, in Columns 2 and 3.

FORM 17

COMPUTATION OF DIAMETER AND HEIGHT GROWTH

PSP 9, Petawawa. Period 1928-1938

Species	—			Diameter Growth—Inches						Height Growth—Feet			
	Diam. Class	Number of Trees		Diameter		Diff.	Diff. Curved	Ave. Ann.		Height		Diff.	Ave. Ann.
		Living	Dead	1928	1938					1928	1938		
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Red Pine.......	4	2	7	4·10	4·10	0	....	....	....	45·2	45·2	0·0	
	5	4	7	5·00	5·00	0	....	....	....	54·0	56·0	2·0	0·20
	6	8	3	5·93	6·07	0·14	0·16	0·02		59·5	64·8	5·3	0·53
	7	10	......	7·05	7·43	0·38	0·32	0·03	....	63·0	69·7	6·7	0·67
	8	17	1	7·97	8·38	0·45	0·48	0·05	....	65·0	72·4	7·4	0·74
	9	7	......	8·94	9·61	0·67	0·64	0·06	....	66·5	74·2	7·7	0·77
	10	13	......	9·93	10·74	0·81	0·73	0·07	....	67·2	75·1	7·9	0·79
	11	9	......	11·12	11·77	0·65	0·82	0·08	....	67·8	75·8	8·0	0·80
	12	9	......	11·96	12·80	0·84	0·84	0·08	....	68·2	76·0	7·8	0·78
	13	8											

(c) Compute the average diameter for the measurements in Columns 2 and 3.

(d) Prepare Form 17. For each diameter class transfer from Form 16 the number of trees still living to Column 3 and from the stand table of dead and removed (Form 9) the number of dead or removed to Column 4, the respective average diameters to Columns 5 and 6.

(e) Calculate the average diameter growth by subtraction (Column 7).

(f) Curve the growth and read growth for integral diameters; enter in Column 8.

(g) Calculate the average annual growth (Column 9).

(h) To obtain the height growth read the heights for integral diameter classes from the diameter-height curves (Form 3) of the respective periods and record in Columns 11 and 12.

(i) Calculate total growth by subtraction and enter in Column 13; enter the average annual growth in Column 14.

(j) The results of these calculations, both in diameter and height growth, should be summarized on Form 18.

Another and more rapid method of determining diameter growth during any period from the stand tables themselves, and not from the growth of individual trees, is by means of an old French method (30a), and an example is worked out in Form 19. This procedure is known as the Double-Rising, Double-Effective method, and takes into consideration trees dying and trees removed during the period.

Form 19:

(a) In Column 2 enter the number of trees in each diameter class at the beginning of the period.

(b) In Columns 3 and 4 the trees dying or removed are entered. Divide these so that, as nearly as possible, equal numbers fall in the same diameter classes in each column; thus these trees are treated as living for one-half of the period (30a. p. 69).

(c) In Column 5 enter the number of trees in each diameter class at the end of the period.

(d) Column 6 is the difference between Columns 2 and 3.

(e) Column 7 is the sum of Columns 4 and 5.

(f) Column 8 (Trees Rising) and 9 (Trees Stationary).

In calculating the number of trees rising out of a diameter class (Col. 8) and the number remaining stationary (Col. 9) the calculation has to begin with the highest diameter class; this class is therefore put at the top of the table.

FORM 18

SUMMARY OF DIAMETER AND HEIGHT GROWTH

PSP 9, Petawawa. Period 1928–1938

Species	Diameter Class	Annual Growth	
		Diameter	Height
	in.	in.	ft.
Red Pine	4	0	0
	5	0	0·20
	6	0·02	0·53
	7	0·03	0·67
	8	0·05	0·74
	9	0·06	0·77
	10	0·07	0·79
	11	0·08	0·80
	12	0·08	0·78

In the example, as no trees have risen above the 16-inch class, this is indicated by a zero in Column 8 *between* the 16- and 17-inch classes.

As no 16-inch trees were found in the original measurements (Col. 6) none was stationary and therefore zero is recorded in Column 9—16-inch class.

As one tree was found in the 16-inch class at the time of the second inventory, this tree must have risen from a lower class, presumably the 15-inch class (Col. 6) therefore 1 is recorded in Column 8 *between* classes 15 and 16.

As this 1 has risen from the 15-inch class, none remained stationary and zero is recorded in Column 9 opposite Class 15.

The computation proceeds down the table in this manner. If trees grow through one entire diameter class, this results in a negative number of trees being stationary.

(g) Column 10 (Double Rising) is the sum of the figures in the two adjacent diameter classes in Column 8. This is double the average number of trees rising in and out of every diameter class.

(h) Column 11 (Double Effective) is the sum of the figures in Columns 6 and 7. It is double the average number of trees contained in each diameter class during the period.

(i) Column 12 is the diameter increment obtained by dividing values in Column 10 by those in Column 11. If two-inch diameter classes were used, this quotient would be multiplied by 2.

(j) Column 13—Values of Column 12 are smoothed by curve.

(k) Column 14—Average annual increment obtained by dividing values in Column 13 by the length of the period; in this case 10 years (1928-1938).

Summary of Compilation Data

Usually each plot is but a single unit in a series established for study of one or more projects. Therefore, when an analysis of the project or projects is contemplated, after one or more remeasurements have been made, it is desirable to assemble, tabulate, and summarize essential information for each plot in a summary statement. The form of this statement should be standardized as far as possible so that the investigator may readily compare results plot by plot without constant reference to the entire plot records.

Crown-Class Distribution Summary. Form 20.—The data from the several tables of crown-class distribution (Form 15), one for each periodic measurement, should be assembled on a single table, Form 20, for purposes of comparison.

Form 19

COMPUTATION OF DIAMETER GROWTH

(Meyer's or French Method)

P.S.P. 9, Petawawa. Period 1928-1938

D.B.H. Class	Inventory 1928	Half of Mortality	Half of Mortality	Inventory 1938	Difference Col. 3 from Col. 2	Sum of Cols. 4 & 5	Trees Rising	Trees Stationary	Double Rising	Double Effective Col. 6 + 7	Increment Col. 10/11	Curved	Average Annual Increment
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Inches												Inches	Inches
17							0	0	1	1	1·00	1·00	0·10
16				1	0	1	1	0	1	1	1·00	1·00	0·10
15	1			0	1	0	0	0	0	0	0	0·97	0·10
14				0	0	0	0	0	8	8	1·00	0·92	0·09
13				8	0	8	8	3	14	20	0·70	0·85	0·08
12	11			9	11	9	6	2	13	17	0·76	0·77	0·08
11	8			9	8	9	7	5	15	25	0·60	0·70	0·07
10	12			13	12	13	8	3	12	18	0·67	0·63	0·06
9	11			7	11	7	4	6	15	27	0·56	0·55	0·05
8	11	1	0	17	10	17	11	8	13	29	0·45	0·43	0·04
7	19	0	0	10	19	10	2	10	2	22	0·09	0·14	0·01
6	13	1	2	8	12	10	0	6	1	13	0·08		0·01
5	10	4	3	4	6	7	1	6	1	13	0·08		0·01
4	10	3	4	2	7	6	0						
	106	9	9	88	97	97	48	49	96	194	0·49		0·05
	−9			+9				48					
	97			97				97					

FORM 20

SUMMARY OF CROWN CLASS DISTRIBUTION

P.S.P. . 51 . . . . Locality . Petawawa .

CROWN CLASS

(In percent of total number of trees)

Date	1	2	3	Total
1921 Before Thinning - 191 Trees				
Saplings	--	22.0	17.2	39.2
Poles	17.2	33.0	5.2	55.4
Standards	4.9	0.5	--	5.4
Total	22.1	55.5	22.4	100
1931 - 127 Trees				
Saplings	--	0.8	25.2	26.0
Poles	12.6	29.1	11.0	52.7
Standards	19.7	1.6	--	21.3
Total	32.3	31.5	36.2	100
1936 89 Trees				
Saplings	--	1.1	12.3	13.4
Poles	33.7	17.9	3.3	54.9
Standards	31.7	--	--	31.7
Total	65.4	19.0	15.6	100

FORM 21

SUMMARY OF SEEDLING TALLY SHEETS

(FOR A SINGLE SUBTYPE AND A SINGLE MAIN-STAND AGE-CLASS)

LOCALITY. Torch. . . . . . SUBTYPE . . . . SITETYPE. As.-Cor.. AGE-CLASS . . . . DENSITY. CLASS. – 150 . . . .

COMPILED BY . . . . DATE . . . .

PLOT No.	SPECIES Spruce						SPECIES Balsam Fir						SPECIES W. Poplar						SPECIES					
	NUMBER OF SEEDLINGS ON PLOT						NUMBER OF SEEDLINGS ON PLOT						NUMBER OF SEEDLINGS ON PLOT						NUMBER OF SEEDLINGS ON PLOT					
	YOUNG (UP TO 20 YRS.)			OLD (OVER 20 YRS.)			YOUNG (UP TO 20 YRS.)			OLD (OVER 20 YRS.)			YOUNG (UP TO 20 YRS.)			OLD (OVER 20 YRS.)			YOUNG (UP TO 20 YRS.)			OLD (OVER 20 YRS.)		
	A (Up to 0.5 ft.)	B (0.5 to 3 ft.)	C (Over 3 ft.)	A (Up to 0.5 ft.)	B (0.5 to 3 ft.)	C (Over 3 ft.)	A (Up to 0.5 ft.)	B (0.5 to 3 ft.)	C (Over 3 ft.)	A (Up to 0.5 ft.)	B (0.5 to 3 ft.)	C (Over 3 ft.)	A (Up to 0.5 ft.)	B (0.5 to 3 ft.)	C (Over 3 ft.)	A (Up to 0.5 ft.)	B (0.5 to 3 ft.)	C (Over 3 ft.)	A (Up to 0.5 ft.)	B (0.5 to 3 ft.)	C (Over 3 ft.)	A (Up to 0.5 ft.)	B (0.5 to 3 ft.)	C (Over 3 ft.)
II-6		4																						
7									1					1	1									
IV 6									1						1									
V 9								3																
VII 1									2					5	1									
5							2	13	6															
9								3						1										
VIII 8							1							5	3									
X 3		1																						
TOTAL		5					3	25	10					12	6									
PER ACRE		222.2					133.3	1111.1	444.4					533.3	266.7									
GRAND TOTAL		222						1688						800										

Reproduction Summary. Form 21.—The data from the several reproduction stand tables (Form 6) should be summarized on a single table (Form 21).

Summary of Stand Tables. Form 22.—It is not practical to include all stand tables in full in the summary of compilation. It would seem to be sufficient for most purposes of analysis to show, for each periodic measurement, the number of trees, the basal area and total volume for all trees, and the merchantable volume for dominant trees. In addition, the supplementary data, average diameter, average height, stand density index, stock intensity index, and mean annual increment should be recorded. The mean annual increment is obtained by dividing the total volume, including all thinnings, by the age of the stand.

FORM 22

SUMMARY OF STAND TABLES (per Acre)

P.S.P. 51—Petawawa

Date	Age	Species	No. of Trees	Basal Area	Total Volume	Merchantable Volume	
				Sq. Ft.	Cu. Ft.	Cu. Ft.	Bd. Ft.
1921	49	Pw	229	51	1,158	...	...
		Sw	579	85	1,851	...	...
Before thinning		Bf	208	22	448	...	...
		Others	84	16	396	...	...
		TOTAL	1,100	174	3,853	...	...

Ave. diam. 5·4″, Ave. Ht. 46′, S.D.I. 459, S.I.I. 83·8, M.A.I. 78·6 Cu. Ft.

1921		Pw	104	18	403		
		Sw	250	14	222		
		Bf	83	4	73		
Material removed		Others	80	15	378		
		TOTAL	517	51	1,076**		
1921		Pw	125	30	751		
		Sw	329	72	1,637		
		Bf	125	18	376		
After thinning		Others	4	...	19		
		TOTAL	583	120	2,783	1,746	2,020

Ave. diam. 6·1″, Ave. Ht. 48′, S.D.I. 262, S.I.I. 57·9, M.A.I. 56·8 Cu Ft.

1941	69	Pw	91	52	1,558		
		Sw	188	90	2,710		
		Bf	46	8	221		
		Others	4	2	47	3,781	11,123
		TOTAL	329	152	4,536*		

Ave. diam. 9·2″, Ave. Ht. 68′, S.D.I. 288, S.I.I. 66·7. M.A.I. 65·7 Cu. Ft.

M. A. I.—Present stand* plus intermediate cutting** 81·3 Cu. Ft.

Form 23

CURRENT ANNUAL INCREMENT AND MORTALITY

Period	Species	Total Stand			Merchantable Stand	
		Net	Mort.	Gross	Net	Net
		Cu. Ft.	Cu. Ft.	Cu. Ft.	Cu. Ft.	Bd. Ft.
1921-41	Pw	40·3	8·7	49·0		
	Sw	53·6	20·4	74·0		
	Bf	−7·7	20·2	12·5		
	Others	1·4		1·4		
Total		87·6	49·3	136·9	101·7	455

Increment and Mortality. Form 23.—The final, and often the most important deduction to be made from the stand tables is the periodic increment, both net and gross. In addition to the increment of the total stand, the increment produced by the dominant trees in cubic and in board feet is usually required. The tabular statement provided for in Form 23 meets these requirements.

The periodic net annual increment is the difference between the volumes at beginning and end of period, divided by the length of period. By addition of annual mortality to net annual increment the gross annual increment is obtained.

The summary of compilation data thus prepared assembles the essential material required for analysis of most projects.

References:

2, 6, 7, 8, 11, 12, 13, 15, 21, 22, 23, 24, 26, 27, 30, 31, 32, 33, 34, 35, 36, 37, 40, 42, 45, 46, 47, 49, 51.

TRANSECT SAMPLE PLOTS

The usual form of transect sample plots is long and narrow; they 'transect' or run across an area to be sampled and thus provide a cross-section likely to include every condition to be found on the area. Each plot is subdivided into small contiguous sections of uniform size. The records for each section are tallied separately, thus affording opportunity to segregate such influencing factors as cover type, site type, density, cutting method, and age class. Sections with like factors may be combined in the compilation stage. The data, if adequate, are therefore susceptible of statistical analysis. Data taken are simpler than those from permanent sample plots and thus many more samples may be taken at no greater cost.

This method of sampling lends itself admirably to simple sampling of stocking, mortality, growth, and reproduction on extensive areas. Advantages of the method over the permanent sample plot method are, according to H. I. Baldwin (4):—

1. The method is simple and economical.
2. It provides a more representative sample.
3. Data are usually fuller, and therefore better adapted to statistical analysis.
4. Effects of subsequent disturbance are less serious.
5. Element of personal judgment in selecting areas is minimized.
6. Tree location map is unnecessary.

It follows, therefore, that the primary purpose of transect sample plots is to sample extensive cut-over lands where conditions are too heterogeneous to be adequately dealt with by permanent sample plots. They provide a means of determining not only the existing conditions, and the progress of development, but also those factors favourable or unfavourable to the development of the stand.

Field Work

Selection of Location.—The method of selecting the location for a transect sample plot or plots is more or less mechanical, particularly if the area to be sampled is extensive and the number of samples to be taken large. Since the purpose is to obtain an adequate number of small samples of not one but all conditions under observation, it is only necessary to ensure that the plots run through the treated area across the contours.

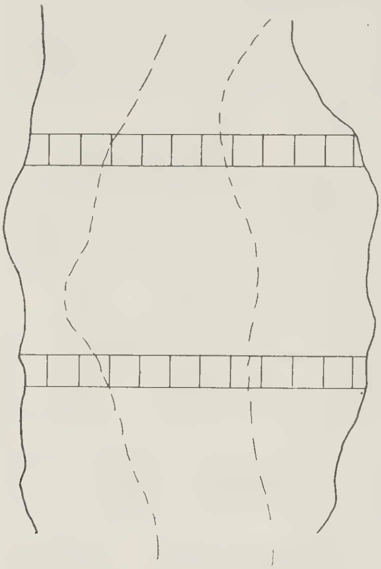


FIGURE 2.—Transect sample plots.

The general location of the area may be determined from the cut-over type map, from which, too, the starting point and bearing of line to each plot may be selected. These points should be readily accessible and easily located for remeasurements as necessary. Apart from this preliminary selection, the samples or sections are taken in a continuous strip. The interval between plots, 10, 20 or more chains, will depend upon several factors, chief of which are the extent of the area, the degree of uniformity of conditions, and partly also the funds available for the study. The number of sections required to provide a reliable average of one or more conditions can only be determined from a statistical analysis of the data as they accumulate. The plots need not all be established in a single season. If, after the first season's data have been compiled, it is found that more samples are required, these may be taken during the following season. Nevertheless, data from a single transect sample plot of 10 or more sections, even though not entirely representative, will yield valuable information and will indicate trends of development.

Size and Shape.—The standard size of a section is one square chain. This area, being one-tenth of an acre, is ideal for compilation purposes. The number of sections per plot is usually not less than 10, and may be as many as required to traverse the area under investigation. Under certain conditions it may be desirable to increase the size of sections to 2 square chains.

Because of their simplicity, and particularly because it is necessary only to locate the hub of the section, instead of relocating the four boundaries, circular sections have been favoured by some investigators. It is contended, however, that a single hub may be more difficult to locate, also that the chances of error are greater in circular plots. In general, the rectangular form has been approved as a standard.

Survey of Plot.—Starting from a tie post, on a road or other transport route, a compass line should be run with hand or staff compass on a bearing that will intersect contours. Pickets should be placed at each end of the chain length as corner posts for a section. Trees along this boundary should be blazed or painted. The parallel boundary should be run one chain distant with a second chain, and the third and fourth corner posts placed at the chain ends. The end boundaries of the sections should be at right angles to the sides. If the four corner posts are clearly marked, it should not be necessary to blaze the other three boundaries.

The tie post must be sufficiently well tied to some identification point along the route for it to be located readily from the description and survey notes. The

TRANSECT TALLY SHEET FORM 24

LOCATION Torch PLOT No. II SECTION No. 6 TALLIED BY E. P. Eisler

SUBTYPE SITETYPE As.-Cor AGE 41-60 DATE Aug. 11, 1943

NUMBER OF TREES 18 AVE. DIAM. 8.1" S.D.I. 128

B.A.	No.	SPECIES / D.B.H. Inches	W. Spruce Living	W. Spruce Dead	W. Poplar Living	W. Poplar Dead	Jack Pine Living	Jack Pine Dead	Balsam Living	Balsam Dead	Spruce Stumps	Living	Dead	Living	Dead	Living	Dead
.005	1	1															
.110	5	2	5														
		3															
087	1	4	1														
.408	3	5	3														
.196	1	6	1														
		7															
.349	1	8	1														
1.326	3	9	1		1				1								
.545	1	10			1						1						
		11															
		12									2						
		13															
		14									1						
		15															
		16															
1.567	1	17					1				1						
1.767	1	18					1										
		19															
		20									1						
6.369	18		12		3		2		1								

SEEDLING TALLY	SPECIES: Balsam						SPECIES: W. Poplar						SPECIES: W. Spruce						SPECIES:					
	NUMBER OF SEEDLINGS ON PLOT						NUMBER OF SEEDLINGS ON PLOT						NUMBER OF SEEDLINGS ON PLOT						NUMBER OF SEEDLINGS ON PLOT					
	YOUNG (0 TO 20 YRS.)			OLD (OVER 20 YRS.)			YOUNG (0 TO 20 YRS.)			OLD (OVER 20 YRS.)			YOUNG (0 TO 20 YRS.)			OLD (OVER 20 YRS.)			YOUNG (0 TO 20 YRS.)			OLD (OVER 20 YRS.)		
	A (Up to 0.5 ft.)	B (0.5 to 3 ft.)	C (Over 3 ft.)	A (Up to 0.5 ft.)	B (0.5 to 3 ft.)	C (Over 3 ft.)	A (Up to 0.5 ft.)	B (0.5 to 3 ft.)	C (Over 3 ft.)	A (Up to 0.5 ft.)	B (0.5 to 3 ft.)	C (Over 3 ft.)	A (Up to 0.5 ft.)	B (0.5 to 3 ft.)	C (Over 3 ft.)	A (Up to 0.5 ft.)	B (0.5 to 3 ft.)	C (Over 3 ft.)	A (Up to 0.5 ft.)	B (0.5 to 3 ft.)	C (Over 3 ft.)	A (Up to 0.5 ft.)	B (0.5 to 3 ft.)	C (Over 3 ft.)
		6	Considerable Balsam on Section.						Nil					4									(OVER)	

bearing of the line, checked frequently by back-sights, must be recorded. The tie post must bear the number of the transect plot. Corner post A of each section must bear the number of the section as well as the number of the transect plot, thus I-I, I-2, etc. Plots should be numbered in roman, sections in arabic numerals, in sequence throughout each plot.

Data Required.—The field data required are:

(1) Survey and tie of plot and sections. (2) Age of stand. (3) Dot tally of diameters. (4) Count of seedlings on reproduction sub-plots. (5) Record of disturbance. (6) Description of topography, soil, and vegetation (all of which may be recorded on a single form). (7) Diameter-height measurements.

Records taken in greater detail defeat the aim of simplicity in the field, and complicate the work of compilation and analysis.

The object of the tally is to provide data for a simple stand table showing the number of trees, basal area, and volume per acre at each remeasurement in each condition under observation. The difference between the stand tables of two measurements represents the stand development during the intervening period.

Tally Sheet. Form 24.—A separate tally sheet must be used for each section.

(*a*) Record location, plot and section number, name of tallyman, and date. Other items in the heading are to be recorded by compiler.

(*b*) Make a dot tally of trees living when section is established. Blaze dead trees. Tally both living and unblazed dead trees at each remeasurement, and blaze those trees that have died since previous measurement. If the project requires it, make a second tally for

HISTORY							FORM 24 (REVERSE)
ORIGIN	VIRGIN		AFTER CUTTING X		AFTER FIRE		AFTER CUTTING & FIRE
LOGGING	LIGHT X	SEVERE	10 YRS. X	20 YRS.	30 YRS.	40 YRS.	NONE
BURN	LIGHT X	SEVERE	10 YRS.	20 YRS.	30 YRS.	40 YRS.	NONE
WINDFALL	LIGHT	HEAVY	10 YRS.	20 YRS.	30 YRS.	40 YRS.	NONE
SLASH	LIGHT	HEAVY	NONE				
SERIOUS INSECT ATTACK	SPECIES			DATE		NONE	

TOPOGRAPHY

SWAMP	FLAT BOTTOM	ROLLING ....X....	HILLTOP ....
SLOPE (G, gentle – S, steep)	LOWER ....G........	UPPER	ASPECT ....N.E....

SOIL

LITTER	THIN (LESS THAN 0.5 IN.)		MEDIUM (0.5 IN. TO 2.0 IN.) X		THICK (OVER 2.0 IN.)
HUMUS	THIN (LESS THAN 0.5 IN.)		MEDIUM (0.5 IN. TO 2.0 IN.)		THICK (OVER 2.0 IN.) X
SURFACE SOIL	SANDY - Silt X	LOAM	CLAY	SHALLOW (LESS THAN 1 FT.)	DEEP (OVER 1 FT.)
SUBSOIL	SAND X		CLAY		ROCK
SOIL MOISTURE	DRY		MOIST X		WET

VEGETATION

GROUND-COVER (PREDOMINANT SPECIES)	SPECIES Aralia	SPECIES Cornus	SPECIES Twin Flower	SPECIES Lycopodium
	Thick Moderate Scattered X	Thick Moderate X Scattered	Thick Moderate Scattered X	Thick X Moderate Scattered
UNDERBRUSH (PREDOMINANT SPECIES)	SPECIES Rose	SPECIES Cranberry	SPECIES	SPECIES
	Thick Moderate Scattered X	Thick Moderate Scattered X	Thick Moderate Scattered	Thick Moderate Scattered
SEED-TREES (PER ACRE) L—LESS THAN 5 TREES PER ACRE M—MORE THAN 5 TREES PER ACRE	SPECIES Pj. L X M	SPECIES L M	SPECIES L M	SPECIES L M
NOT IMPORTANT (2)				

(1) USE CROSSES (X) TO FILL IN FORM WHEREVER POSSIBLE.
(2) BY "NOT IMPORTANT" IS MEANT THAT MAIN STAND IS ALREADY PRESENT FROM WHICH SEED IS AVAILABLE FOR REGENERATION.

defective trees. Tally stumps, separating them by date of cut. These data may be of value in measuring returns, as well as effect of disturbance.

(c) Establish a permanent reproduction subplot 3·3 feet × 66 feet (1/200 acre), preferably along the boundary remote from the survey line, to avoid unnecessary disturbance to seedlings.

(d) Count and record numbers of seedlings by species, separating them into the three height classes provided for on Form 24.

(e) Record historical, topographic, and soil data provided for in the form, by check mark or cross.

(f) Record occurrence of at least four species of herbaceous plants, and of four shrubs or undergrowth, indicating whether their occurrence is frequent, moderate, or scattered. To avoid confusion, botanical names should be used at least for the herbaceous plants. Mosses or grasses are of little or no value as indicators unless the species are given.

Diameter-Height Data. Form 25.—Reliable diameter-height curves for each species and site type are essential for computation of volume. Furthermore, since the relationship between diameter and height tends to change with passing of time, new diameter-height curves should be prepared every five, or, at most, every ten years. For this purpose measurements should be taken on at least five trees on every section. A minimum of fifty trees is necessary for each curve.

Diary.—A diary should be started with the establishment of each plot and maintained throughout the life of the project. The diary should cover progress in compilation as well as field work.

FORM 25

TREE-HEIGHT RECORD

Height in feet. Diameters in inches

TRANSECT SAMPLE PLOT No.......... LOCALITY ....

MEASUREMENTS BY.......... NOTES BY.......... DATE.......... CHECKED BY.......... DATE ....

INSTRUMENT AND ARC USED .... TAPE USED ....

SECTION No.	TREE No.	Species	D. B. H.	Distance	Reading To Top	Reading To B. H.	Total Height	AGE AT S.H.	SECTION No.	TREE No.	Species	D. B. H.	Distance	Reading To Top	Reading To B.H.	Total Height	AGE AT S.H.
1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9

INSTRUMENT READING TO B. H.—If B. H. is below instrument level the value will be minus. , If above instrument level it will be plus. In either case the sign must be recorded.

TO OBTAIN HEIGHT—(1) Add the minus value, or subtract the plus value of column 7 to or from the value of column 6. (2) Multiply the resultant factor (a decimal value) by the distance, column 4. (3) Add the breast-high elevation, 4.5 feet. (4) Record the result to the nearest foot in column 8.

Remeasurement.—Measurements and remeasurements should be made either before the growing season commences or after it has ended. If that is not feasible, remeasurements should be made at the same time of the year that the establishment measurements were made.

Procedure:

(*a*) Locate the four corner posts of each section. Re-establish them if they have been disturbed; replace them if they have decayed.
(*b*) Mark out the section by string or tape.
(*c*) Tally all living and all unblazed dead trees. Blaze the latter.
(*d*) Make a recount of seedlings on the reproduction subplots.
(*e*) Make notes of any disturbances that may have occurred since the previous measurement.
(*f*) Take diameter-height measurements.
(*g*) Write up diary records.

Compilation

Mapping.—The location of the plots and position of reproduction subplots on each section should be shown on the cover type map.

Completion of Tally Sheets. Form 24.—The various factors under observation, and considered likely to influence growth, must be determined and entered on each field tally sheet (Form 24). The most important of these factors are site type, density, cover type, and age class.

Base the cover-type designation on the basal area representation of species. Site type may be based on height of dominant trees of a given age, on topography, or (preferably) on vegetation.

If a satisfactory vegetation site-type classification for the region is not available, it may be determined from an analysis of topography, soils, vegetation, and cover type. Such an analysis involves subdivision of the samples into the several topographic and soil groups, and listing the vegetation and tree species on each plot. In the list, the frequency of occurrence should be given some numerical weight. A scale value of 3 for thick, 2 for moderate, and 1 for scattered will usually be adequate.

From an examination of the data thus compiled, two or three indicator species suitable for a site-type name may be selected. Any site types thus chosen should be described as to topography, soil, and characteristic species of vegetation, including trees. Age may be recorded in twenty-year classes; or in four age groups (see Appendix I, Forest Terminology).

Calculate for each section the stand density index, based on basal area and number of trees.

SUMMARY OF TALLY SHEETS

(FOR A SINGLE SPECIES IN A SINGLE SECTION)

FORM 26

LOCALITY Torch SUBTYPE B.S. SITE TYPE As-Cor. AGE-CLASS 61-100, DENSITY CLASS -1.50

COMPILED BY J.O. Smith DATE Jany 1944

SPECIES: Spruce

TALLY SHEET NO.		DBH 1	2	3	4	5	6	7	8	9	10	11	12	13	TOTAL
II	6	–	5	·	1	3	1	–	1	1					
	7	2	–	1	2	2	1	1	–	1	1				
IV	6	8	1									1	1		
V	9	1	4	2			1								
VII	1	3	3	1	3			1	1	1	2	1			
	5	11	11	12	1	2	1	1	3					1	
	9		2	1	2				1			2			
VIII	8	1								1					
X	3	4								1					
Total		30	26	17	9	7	4	3	6	5	3	4	1	1	116
Average per Acre		33.3	28.9	18.9	10.0	7.8	4.4	3.3	6.7	5.6	3.3	4.4	1.1	1.1	129

TRANSECT STAND TABLE (AVERAGE PER ACRE)

FORM 27

LOCALITY Torch SUBTYPE O.S. SITETYPE As-Cor. AGE-CLASS 61-100 DENSITY CLASS -1.50

BASIS, No. OF SECTIONS 25 AVE. DIAMETER 4.2" AVE. HEIGHT S.D.I. 941 S.I.I.

COMPILED BY J.O. Smith DATE Feby 1944

SPECIES	Spruce			B. Fir			Jack Pine			W. Poplar			B. Poplar			Birch			TOTAL		
D.B.H. CLASS	No	Merchantable Volume		No.	Merchantable Volume		No.	Merchantable Volume		No.	Merchantable Volume		No.	Merchantable Volume		No	Merchantable Volume		No.	Merchantable Volume	
INCHES		CU. FT.	BD. FT.		CU. FT.	BD. FT.		CU. FT.	BD. FT.		CU. FT.	BD. FT.		CU. FT.	BD. FT.		CU. FT.	BD. FT.		CUBIC FEET	BOARD FEET
1	33.3			127.8						17.8						4.4			183.3		
2	28.9			38.9															61.8		
3	18.9			22.2															41.1		
4	10.0	3.0		4.4	1.3														14.4		
5	7.8	10.4		5.6	7.4														13.4		
6	4.4	12.1		1.1	3.0														5.5		
7	3.3	15.7		2.2	10.3														5.5		
8	6.7	49.2		2.2	16.1					4.4	44.4								13.3		
9	5.6	59.4		2.2	23.3					2.2	29.5								10.0		
10	3.3	46.9		1.1	15.7					3.3	56.8								7.7		
11	4.4	81.4								1.1	22.9								5.5		
12	1.1	25.4		1.1	25.3					2.2	58.7								4.4		
13	1.1	30.8								1.1	35.4								2.2		
14																					
15																					
16																					
17							1.1	56.0											1.1		
18							1.1	62.9											1.1		
19							1.1	70.5											1.1		
TOTAL	128.8	334.3		208.8	102.4		3.3	189.4		32.1	247.7					4.4			377	873.8	

Summary of Tally Sheets. Form 26.—How the sections may be grouped will depend upon the number taken. The minimum number of subdivisions will probably be three density classes, three cover types, one site type, and one age class, that is, nine subdivisions. The factor of density probably exerts the greatest influence on reproduction, and may equal that of site on growth. Three density classes will usually be sufficient to cover the situation:—

1. Open; up to, say, 150 S.D. Units.
2. Understocked; 151 to 250 S.D. Units.
3. Fully stocked; over 250 S.D. Units.

After the field forms (Form 24) have been completed, they should be sorted into like sub-types, age classes and density classes.

Summarize the number of trees in each diameter class and species on Form 26, and calculate the number per acre.

Stand Tables. Form 27.

(a) Transfer the number per acre from Form 26 to stand table, Form 27.
(b) Prepare diameter-height curves, Form 13.
(c) Select the desired volume table or tables and prepare the diameter-volume curves, Form 14.
(d) Calculate the volumes to complete the stand table.
(e) Calculate the average diameter, average height, S.D.I. and S.I.I., for each stand table. The S.D.I. and S.I.I. are exponential and therefore the averages for a group of sections are obtained by averaging the S.D.I. and S.I.I. of the individual sections.

A similar stand table should be prepared for mortality.

Reproduction.—Transfer the number of seedlings per subplot from Form 24 to Summary Form 6. Compute the number of seedlings per acre to complete the reproduction stand tables.

References:

4, 28, 32, 35, 36, 39, 42, 47.

LINE-PLOTS

The line-plot system of forest surveying was introduced as a modification of the strip system for single-examination enumeration surveys. Its chief disadvantage lies in the small area sampled, but this disadvantage is generally considered to be outweighed by its advantages, which are:

1. With sufficient plots, the data may be subjected to statistical analysis.
2. The records may be grouped or classified at will.
3. The boundaries of each plot or unit are measured, and therefore the data tend to be more accurate.
4. The number of variant factors on a plot is small.

In view of these facts it is now being used as a semi-permanent method for working plan and rate-of-growth surveys on extensive areas, where periodic check surveys are required. Although the data obtained are less accurate than those provided by permanent or by transect sample plots, much larger areas may be sampled for the same cost. Hence the extent of the area to be sampled and the accuracy required must in large measure be the deciding factors in the choice of method for any given investigation.

Field Work

Selection of Area and Location of Plots:—The area or areas to be cruised should be selected from the cover-type map if one is available. Aerial type maps are the best for this purpose. On these, bodies of water or waste land, which need not be cruised, are shown, and these areas may be eliminated from consideration before ground work begins. Boundaries, base lines, and roads which may be

used as base lines or as routes of travel should be shown on the map. If the purpose of the survey is concerned only with specified cover types, these also may be delineated and noted.

Beyond this preliminary selection of the area the location of lines and plots is determined mechanically and without the influence of personal judgment, an important requirement for purposes of statistical analysis. Decision as to the interval required between lines and plots must be based upon the extent of the forest universe, the degree of regularity of the numerous factors which influence growth and stocking, and the precision desired in the results.

The interval between plots having been determined, the approximate location of the lines and the plots on each line may be recorded on the map. Then it only remains for the surveyor to locate the starting points in the field and to run his lines on the predetermined bearings. He may know in advance the chainage at which the type changes, or his line should end, and avoid unnecessary traverse of waste areas. The usual interval between lines and plots is ten chains. On large areas, when stand composition and conditions are fairly uniform, the interval may be increased to 20, or even to 40 chains. By subjecting the data collected to a statistical analysis as the work progresses, the number of plots likely to be required to provide a satisfactory sample of the area can be determined.*

If the plots are to be remeasured periodically, the compass bearing must be carefully read and recorded; the line must be clearly blazed. The hubs of circular plots, and the corners of rectangular plots, must also be marked. In either method the plot should be marked out by tape or string before tallying.

Tie-in posts should be plainly marked and numbered. Plots should be numbered in a single sequence throughout the whole survey. When more than one sequence of numbers is used in a single project, errors or confusion frequently occur in compilation and remeasurement stages. Base lines and the location of tie posts should be so described that they can be readily relocated at any time.

Mapping notes showing the location and ties of the line and plots should be taken along each line. Prominent features, such as streams and hills, roads and trails, and boundaries of cover types should be noted as a check with the cover-type map.

Tally Sheet. Form 24.—The same tally as described for transect samples should be taken for each line plot. In addition, the trees estimated to have died within 10 years are also to be recorded if the increment is to be determined from borings. If the plots are to be remeasured periodically these dead trees must be blazed so that they will not be included in subsequent remeasurements.

Diameter-height Data.—Diameter-height data must be taken as for transect samples, Form 25.

Increment.—Current increment may be determined either from increment borings, or by comparison of measurements of the same stand taken at periodic intervals. Because of the uncertainty in determining the mortality that has occurred in the past, and because of errors in measuring radial increment, the

*The size and shape of plots is usually one square chain, but some investigators prefer circular plots of one-quarter acre. On the Ohio Forest Survey (Works Projects Administration Forestry Publication No. 71, 1942), square sample plots, one-fifth of an acre in area, were laid out from diagonal measurements from a central point, by the following procedure:—

(a) Place pickets A and B on the compass line, one at each end of the two-chain tape.
(b) Set up alidade midway between pickets A and B—the centre of the plot.
(c) Turn off right angles to the base line with the alidade and set pickets C and D at one chain distance, one on each side of the compass line. The lines joining the four pickets form the boundaries of a fifth-acre square plot.
(d) Place an identification post in the centre of the plot.

Advantages of the method are:

1. A single set-up of instrument is all that is required.
2. A single identification post in the centre is all that is required.
3. There is no need to check measurements between the corner pickets.
4. No permanent corner posts are required.
5. A fifth point, the centre, is provided for control of tally.
6. The unit is double the size of the parallel plots and therefore is a better sample.

The principal disadvantage of the method is that extra equipment (alidade, tripod, and four sighting pickets) must be carried.

reliability of the former method is sometimes questioned. Recent resurveys of areas originally examined by the increment-boring method indicate that, although the tendency seems to be to underestimate the mortality, nevertheless the net increment thus determined has not been too high.

For immediate estimates of increment we must continue to depend upon this method until a suitable yield table method can be developed. For this purpose increment borings should be taken on at least fifteen trees in each diameter class for each important species, site type, age class, and density class. Two borings, on opposite sides of the tree, should be taken for each tree, the object being to make correction for eccentricity in growth rings. The total radial growth at breast height for the past ten years should be recorded on Form 28.

INCREMENT-BORING RECORDS—TALLY SHEET No. FORM 28

AREA .... BLOCK .... DRAINAGE

MEASUREMENTS BY .... RECORDED BY .... DATE ....

PLOT NO.	TREE NO.	TYPE	SPECIES	D.B.H.	BARK	RADIAL GROWTH LAST		TOTAL AGE AT D.B.H.	TOTAL HT.	PLOT NO.	TREE NO.	TYPE	SPECIES	D.B.H.	BARK	RADIAL GROWTH LAST		TOTAL AGE AT D.B.H.	TOTAL HT.
						10 YEARS	20 YEARS									10 YEARS	20 YEARS		
				Ins.	Ins.	Ins.	Ins.	Yrs.	Feet					Ins.	Ins.	Ins.	Ins.	Yrs.	Feet

The most satisfactory method of measuring increment is by periodic measurement of samples, which eliminates the uncertainty involved in determining mortality. The long time element involved is the drawback to this method: although it does not require the taking of borings, the desirability of applying both methods in any survey of this nature should always be considered.

Compilation

Mapping.—The field notes should be transferred to the cover-type map. The location of base lines and ties, lines and plots, cover-type boundaries as crossed by the lines, and of topographic features should be shown.

When it is proposed to resurvey the blocks it is desirable to have a larger-scale map, on a scale of ten or twenty chains per inch, on which the above information may be given in greater detail. Notes on stand, type, density and disturbance may be recorded for each plot after the tally sheet data have been compiled.

Stand Tables and Increment.—When increment is to be determined by the remeasurement method, tally sheets should be completed and sorted, and the stand tables prepared as described for transect samples, Form 27 (for the increment-boring method the stand for the past, as well as for the present, must be shown on a single stand table). Transfer the increment data from field tally sheet (Form 28) to Form 29, sorting for the various factors such as species, site types, and age, density and diameter classes, and compute the diameter increment for each species and diameter class; plot the results in a diameter-increment curve.

(a) Transfer the number of trees per acre, both living and dead, from Form 26 to the *first section* of Form 30, *using a separate sheet for each species.*

(b) Compute the volumes and total number of trees and volume.

(c) Reduce the diameter of the respective inch classes of the present stand by use of the diameter-increment curve and enter in the second section of Form 30.

(d) Calculate the volumes for the reduced diameters. Total the number of trees and their volume.

(e) On one sheet of Form 30 enter the total numbers of trees and volumes, both present and past, for each species. Total all species. The difference between the volume of the "present" stand, and that of the "past" stand, divided by the length of period, represents the periodic gross annual increment, from which mortality must be subtracted to obtain the net increment.

(f) Compile the reproduction stand table (Form 6) as described for permanent sample plots.

References:

13, 14, 23, 26, 27, 30, 35, 36, 43, 47, 48, 51, 55, 61, 63, 64.

INCREMENT-BORING RECORDS—SUMMARY OF TALLY SHEETS, FORM 29
(FOR A SINGLE SPECIES AND SUBTYPE)

AREA .... DRAINAGE .... SPECIES .... SUBTYPE ....

COMPILED BY .... DATE .... CHECKED BY .... DATE ....

DIAMETER CLASS ....INCHES

PLOT No.	TREE No.	D.B.H.	BARK	RADIAL GROWTH IN LAST 10 YEARS	RADIAL GROWTH IN LAST 20 YEARS	TOTAL AGE AT D.B.H.	TOTAL HEIGHT
		Ins.	Ins.	Ins.	Ins.	Yrs.	Feet
5							
10							
15							
20							
TOTAL							
AVERAGE							

DIAMETER CLASS ....INCHES

PLOT No.	TREE No.	D.B.H.	BARK	RADIAL GROWTH IN LAST 10 YEARS	RADIAL GROWTH IN LAST 20 YEARS	TOTAL AGE AT D.B.H.	TOTAL HEIGHT
		Ins.	Ins.	Ins.	Ins.	Yrs.	Feet
5							
10							
15							
20							
TOTAL							
AVERAGE							

FORM 30

GROWTH STAND TABLE (AVERAGE PER ACRE)

UNIT .... TYPE .... AGE-CLASS .... SPECIES* ....

COMPILED BY .... DATE .... CHECKED BY .... DATE ....

SPECIES OR DIAMETER-CLASS	PRESENT STAND—YEAR 19........ LIVING			DEAD		PAST STAND—YEAR 19........				NET ANNUAL INCREMENT		
	UNIT VOLUME	NUMBER	VOLUME	NUMBER	VOLUME	REDUCED DIAM.	UNIT VOLUME	NUMBER	VOLUME	TOTAL	MERCHANTABLE VOLUME 4" TO 9"	MERCHANTABLE VOLUME OVER 9"
Inches	Cu. Ft.		Cubic Feet		Cubic Feet	Inches	Cu. Ft.		Cubic Feet	Cu. Ft.	Cubic Feet	Ft. B.M.
TOTAL												

* If used for all species, write "ALL"; if for one species, name the species.

TEMPORARY PLOTS

Temporary plots serve chiefly for collection of data for quantitative studies and for mensuration projects. Data for yield tables, site-type classification, and form class may be collected by temporary plots. Line-plot surveys for stock-taking and growth studies are frequently of this class. The data collected vary with the nature of the study. In general, a large part of the detail for line-plot work applies to this method of study (51).

The selection of the location for temporary plots must be governed by the purpose of the project. For collection of normal yield, site type, or taper data the location is in fully stocked, pure, even-aged stands, but for enumeration surveys the location is usually made mechanically. The size varies from one-tenth to one-half acre, depending upon the purpose of the study and the uniformity of the stand. For enumeration surveys it is usually one square chain, or one-quarter acre for circular plots. Except for the measurement of the area of these plots, or for the mechanical distribution of those intended for enumeration surveys (when the interval between plots must be measured), no survey is required.

The data required depend entirely upon the purpose of the project. The minimum requirements will usually be a tally of living trees by species and diameter classes, some height measurements, and a detailed description of the area and stand. Almost invariably the age of the stand, site type, and density are essential. Data on reproduction and vegetation are recorded from sub-plots or quadrats. Details of methods for collecting, compiling, and analysing data must be outlined for each specific project.

SUBPLOTS

A subplot is a subdivision of a sample plot, used for the purpose of recording data too detailed to be recorded for a full sample plot. Its principal purpose is to record reproduction, and for this purpose one or more subplots are required on most permanent, transect, and line plots. It is also the basis for studies of sucker growth and mortality, effect of seed-bed treatment, and effect of slash and slash disposal methods upon regeneration.

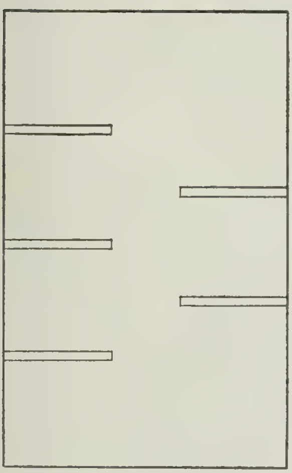


Figure 3.—Subplots.

Sometimes the term subplot is applied to small plots, entities in themselves, and having no direct relation to any larger sample plot. Such use of the term is apt to be misleading, and should be avoided.

Heretofore the size and shape of subplots have varied according to the purpose of the project or the plan of the investigator. Dimensions commonly used were 20 feet square, one square rod, or one square yard. Experience has shown that long, narrow subplots have certain definite advantages over square plots, namely:

1. They can be examined without need of stepping over the border, thus avoiding disturbance of the vegetation concerned.
2. A more accurate tally is possible.
3. They provide a more representative sample of the vegetation.
4. They lend themselves to subdivision into quadrat sections, an important feature in measuring distribution of vegetation and in providing a means for statistical analysis.

PHOTO. 8.—Reproduction subplot 3·3 × 66 feet, bounded on long sides by string and tape. Poles subdivide plot into quadrats. (Photo. No. 22558).

Irregularity in the area of subplots often leads to confusion and error. For these reasons the approved standard dimensions are 3·3 feet × 66·0 feet—1/200 acre. Wherever reproduction is, or is likely to be, a factor in the study, five subplots should be established on each permanent sample plot of half an acre or more, and one or more subplots on each transect sample plot or line plot.

Details of survey, collection, and compilation of data are given under permanent and transect sample plot description.

QUADRATS

In forest research the term quadrat commonly signifies a small rectangular subplot, usually square or a uniform section of a subplot; its purpose is to record the frequency distribution of reproduction. Subplot records may show that the number of seedlings per acre is more than sufficient for future needs. However, these may be concentrated on a comparatively small area of the plot or subplot, where conditions are abnormally favourable, and under these unsatisfactory distribution conditions the plot may actually be inadequately stocked. The methods and principles governing transect plots and line plots apply on a reduced scale to quadrat plots for the study of reproduction and small vegetation. Quadrat plots are also adapted to intensive studies of such fundamental factors as soil, moisture, and light. Their size is seldom more than 5 feet square, so that they may be examined without crossing the border. They may be contiguous sections of a subplot, or they may be mechanically distributed as line plots. As sections of a subplot the standard dimensions are 3·3 feet square, 20 per subplot. As sections of a permanent or a transect plot, or as line plots, the size may be somewhat larger if the purpose of the project so requires.

Quadrat plots are usually of the permanent type, but may be laid out for single examination. When they are to be permanent the location survey must be in sufficient detail to allow them to be readily relocated at any time. Because of the small size of the plots, little or no error is permissible in boundary measure-

ments. Fixed or collapsible frames are recommended for bounding line-plot quadrats. If the sides of subplots are bounded by string, two poles $3 \cdot 3$ feet long will be found a convenient means of subdividing the subplot into quadrats.

The nature and detail of records will depend largely upon the purpose of the project. Most investigations employing quadrats involve fundamental studies, such as details of soil, ground-cover conditions, and disturbances that may have some influence on the factor under observation. Irregular distribution of reproduction may be attributable to variations in soil, moisture or light conditions, or to disturbances caused by skidding trails or slash disposal methods. It may be necessary to map these features on each quadrat, and to note the occurrence of the reproduction in relation to these factors. The details of records required should be covered in the outline or project plan for the project.

Methods of compilation and analysis must be left to the judgment of the investigator. In so far as they apply the methods outlined for permanent and transect plots and for subplots may be followed as a basis.

References:
3, 20, 30.

RAUNKIAER PLOTS

Certain projects in botany and ecology, notably vegetation site-type, classification, require a statistical study of the occurrence of herbaceous plants or ground-cover. Obviously the prolific occurrence of these species makes it imperative that the area of samples be very small and precisely measured, while their number must be large.

In his publication, "Investigations and Statistics of Plant Formations" 1909-10, Dr. C. Raunkiaer (34) described 'a method of making a floristic analysis of a number of areas of a definite size taken at random in the formation to be investigated to determine the degree of frequency of the individual species'.

After investigating the relative values of samples 10 square metres, 1 square metre, 1/10 square metre, and 1/100 square metre in area, he concluded that '1/10 square metre is the unit area found best; it appears to give the result most in harmony with reality, and at the same time the floristic analysis of the individual areas is not particularly difficult, and the number of investigated areas does not need to be so very large to attain a stable result'.

There is still some difference of opinion as to the most satisfactory size of the unit, but that of 1/10 square metre appears to be the most favored size, and is generally accepted as the standard.

The original shape of the plot adopted by Raunkiaer was square. Later he replaced the square by a ring subdivided by spokes into four radial sections of five-, two-, two-, and one-tenths. Raunkiaer concluded that fifty plots were necessary for an adequate sampling of a universe. Later investigations indicate that twenty-five samples are sufficient and this number is now generally accepted.

There is division of opinion as to whether the taking of samples should be random or systematic. This Service prefers and has adopted the latter method, the ring being dropped at each ten double paces.

To determine the frequency of occurrence of species, it is only necessary to determine the number of plots on which one specimen of the species is found, and this frequency may be expressed in percentage of the total number of plots examined. For occurrence distribution it is necessary to estimate the proportion of plot occupied by each of the species, expressed in percentage of the plot area: it is for this purpose that the ring is divided into sections of $0 \cdot 5$, $0 \cdot 2$, $0 \cdot 2$, and $0 \cdot 1$.

The method of compiling and analyzing the data is a matter for the judgement of the investigator.

References:
23, 27, 34, 40.

Photo. 9.—Dense red pine stand in need of thinning. (Photo. No. 26255).

STAND DENSITY

Yield tables, whether normal or empirical, are based on the density of the stand. Heretofore yield tables have been prepared from samples which the investigator considered, largely from observation, to be fully stocked. The only means of measuring density were numbers of trees, total basal area, or total volume. But, since volume does not vary directly with number of trees, these measures are unsatisfactory. L. H. Reineke (36) has developed a method of measuring density by means of numbers of trees and average diameter. G. A. Mulloy (32) has checked his method and prepared stand density index tables whereby the density of any stand or sample plot may be computed. Stand density thus measured can be used as a control in regulating degrees of cutting in thinning, improvement cutting, and harvest cutting projects. Calculation of stand density should constitute a part of the computation of sample plot and survey data just as much as computation of number of trees, basal area, or volume.

In selecting a series of comparable plots, stand density is a reliable indicator of degree of similarity. After plots have been thus selected, the amount to be removed from each sample plot should be regulated by stand density instead of by numbers of trees or by volume. Stand density provides one means of measuring the effect of treatment, whether it is thinning, improvement cutting or harvest cutting: it also provides a means of measuring the allowable cut, as illustrated below.

To calculate stand density:

(a) Determine the average diameter by dividing the total basal area by the number of trees, and by reading the corresponding diameter from basal area tables.

(*b*) Read the stand density unit for the tree of average diameter from the stand density unit table (p. 56).

(*c*) Multiply the unit by the number of trees per acre.

Example: The average diameter of a control plot containing 650 trees per acre (about 8 feet apart) is 6·2 inches. The stand density is therefore ·464 unit × 650, or 302 units. It is desired to reduce a second plot to 225 S.D.I. by thinning from below, to compare the resulting growth rate with that of the control plot.

The second plot contains 622 trees (spaced at 8·4-foot intervals), average diameter 6·2 inches. Its density is ·464 unit × 622, or 289 units. To reduce to S.D.I. of 225, this must be reduced 64 units by removing trees of an average of 5·0 inches D.B.H. The density of one 5-inch tree is ·329 unit, therefore 64 units will require $\frac{64}{.329}$, or 194 five-inch trees. After thinning, the stand will contain 428 trees (spaced at 10-foot intervals), average diameter 6·7 inches, 225 S.D.I. Various diameters should be selected for removal.

In unregulated harvest cutting little or no consideration is given to variations in the density of the remaining stand, with the result that certain sections of the stand are left in an understocked condition. By use of stand density measure the cut may be so regulated as to leave the remaining stand at a uniform density likely to produce the maximum volume increment. If, as in the case of the previous example, the desired density is 225 units, the cutting should be regulated to leave 428 trees averaging 6·7 inches D.B.H., which calls for a spacing of 10 feet. This procedure will, of course, result in an irregular volume harvest for the first cutting cycle, but in future operations both volume cut and volume remaining will tend to be constant, and the density will be favourable to growth.

References:

7, 32, 36.

TIME AND COST RECORDS

Time and cost records are important for two purposes, namely:

1. To estimate expenditures involved in particular projects.
2. To determine, by comparison with costs of other similar projects, whether the expenditures are reasonable.

If these data are to be neither too scanty nor too detailed to serve the foregoing purposes to the best advantage, the methods of taking records and analyzing them must be standardized.

Division between items that may be classed as indirect or overhead costs and those constituting direct costs must be clearly recognized in any standard cost set-up. Cost of office staff (including compilers), transportation (including daily travel to and from the project), equipment, and depreciation vary so greatly with organization and location of project that they should be treated as overhead expenses and should be separated from expenditures for field labour.

Except where cost accounting is itself the primary subject of investigation, the purposes of time records do not warrant stop-watch precision. Records taken to the nearest hour should be sufficiently accurate even for the subdivision of the more detailed permanent sample plot data.

Research Costs

The relatively high proportion of the indirect costs required for the technical staff necessarily involved in research has, of course, no bearing on the probable costs of applied silviculture. Nevertheless, without reliable information on comparable costs of any class of project, it is impracticable to prepare estimates for funds for its prosecution. Furthermore, time records provide the most generally reliable means of checking work efficiency.

STAND DENSITY UNITS

Diam.	Unit S.D.I.	Diam.	Unit S.D.I.	Diam.	Unit S.D.I.	Diam.	Unit S.D.I.	Diam.	Unit S.D.I.	Diam.	Unit S.D.I.	Diam.	Unit S.D.I.	Diam.	Unit S.D.I.	Diam.	Unit S.D.I.	Diam.	Unit S.D.I.
1·0	0·025	2·0	0·075	3·0	0·145	4·0	0·229	5·0	0·329	6·0	0·440	7·0	0·564	8·0	0·699	9·0	0·844	10·0	1·000
1	0·029	1	0·082	1	0·153	1	0·239	1	0·340	1	0·452	1	0·577	1	0·713	1	0·859	1	1·016
2	0·033	2	0·089	2	0·161	2	0·249	2	0·351	2	0·464	2	0·590	2	0·727	2	0·874	2	1·032
3	0·037	3	0·096	3	0·169	3	0·259	3	0·362	3	0·476	3	0·603	3	0·741	3	0·889	3	1·048
4	0·042	4	0·103	4	0·177	4	0·269	4	0·373	4	0·488	4	0·616	4	0·755	4	0·904	4	1·064
5	0·047	5	0·110	5	0·185	5	0·279	5	0·384	5	0·500	5	0·629	5	0·769	5	0·920	5	1·080
6	0·052	6	0·117	6	0·193	6	0·289	6	0·395	6	0·512	6	0·643	6	0·784	6	0·936	6	1·096
7	0·057	7	0·124	7	0·202	7	0·299	7	0·406	7	0·525	7	0·657	7	0·799	7	0·952	7	1·113
8	0·063	8	0·131	8	0·211	8	0·309	8	0·417	8	0·538	8	0·671	8	0·814	8	0·968	8	1·130
9	0·069	9	0·138	9	0·220	9	0·319	9	0·428	9	0·551	9	0·685	9	0·829	9	0·984	9	1·147
11·0	1·164	12·0	1·339	13·0	1·523	14·0	1·715	15·0	1·916	16·0	2·126	17·0	2·343	18·0	2·568	19·0	2·801	20·0	3·042
1	1·181	1	1·357	1	1·542	1	1·735	1	1·937	1	2·147	1	2·365	1	2·591	1	2·825	1	3·066
2	1·198	2	1·375	2	1·561	2	1·755	2	1·958	2	2·168	2	2·387	2	2·614	2	2·849	2	3·091
3	1·215	3	1·393	3	1·580	3	1·775	3	1·979	3	2·189	3	2·409	3	2·637	3	2·873	3	3·115
4	1·232	4	1·411	4	1·599	4	1·795	4	2·000	4	2·211	4	2·431	4	2·660	4	2·897	4	3·140
5	1·249	5	1·429	5	1·618	5	1·815	5	2·021	5	2·233	5	2·453	5	2·683	5	2·921	5	3·165
6	1·267	6	1·447	6	1·637	6	1·835	6	2·042	6	2·255	6	2·476	6	2·706	6	2·946	6	3·190
7	1·285	7	1·466	7	1·656	7	1·855	7	2·063	7	2·277	7	2·499	7	2·730	7	2·970	7	3·215
8	1·303	8	1·485	8	1·675	8	1·875	8	2·084	8	2·299	8	2·522	8	2·754	8	2·994	8	3·240
9	1·321	9	1·504	9	1·695	9	1·895	9	2·105	9	2·321	9	2·545	9	2·777	9	3·018	9	3·265

To Obtain Stand Density Index

May, 1943 Multiply the unit by the number of trees per acre Dominion Forest Service

The following subdivision is recommended as standard for research projects:

Permanent Sample Plots—Time in Man-hours:

1. Survey (boundaries, subdivisions, subplots, tie, setting posts and pickets).
2. Tagging and mapping trees.
3. Measuring diameters.
4. Measuring heights.
5. Counting reproduction.
6. Treatment (marking, cutting, and removing).

Calculate:

(a) Total man-hours, all phases.
(b) Total man-days (of 8 hours) per acre.
(c) Cost of entire project on a fair average rate per man-day, including board.

Transect Sample Plots—Time in Man-hours:

1. All phases combined, except treatment, if any.
2. Treatment, all phases combined.

Calculate:

(a) Total man-hours per plot (not per sample).
(b) Total man-days per acre.
(c) Costs per acre.

Line-Plots—Time in Man-hours:

1. All phases combined per acre (10 plots).

Calculate:

(a) Number of man-days per acre.
(b) Costs per acre.
(c) Costs per day.

Applied Silviculture Costs

Costs of primary interest in applied silviculture are those concerned with operations or treatment. These should be credited with immediate returns. Only when the stand improvement is likely to result in immediate returns in excess of the present net cost can the project be justified.

The following subdivision should be suitable for any class of treatment—thinning, improvement cutting, or harvest cutting.

Time to be recorded in man-hours:

1. Marking, per area, per acre, per unit volume (M Ft. B.M. or cord).
2. Cutting, per area, per acre, per unit volume.
3. Skidding, man-hours, and horse-hours, per area, per acre, and per unit volume.
4. Hauling, man-hours, and power-hours per area, per acre, per unit volume, per mile.
5. Slash disposal, per area, per acre, per unit volume.

Calculate:

(a) Total man-days in each phase and each unit.
(b) Total man-days, all phases.
(c) Total costs at fair average rate, including board for each phase, and each unit.
(d) Total cost of project, all phases per acre.
(e) Total returns from project per acre.
(f) Increased increment in growth and quality per acre likely to result should be estimated and compared with the net cost, from which some conclusion of the value of the project may be deduced.

POSTS, PICKETS, SIGNS

The corners of all permanent and semi-permanent sample plots, also survey tie-in points, should be marked by suitable permanent posts. Permanent sample plot subdivision terminals, subplot corners, and transect samples should be indicated by permanent pickets. Suitable direction and information signs should be used on trails or approaches to sample plots or areas, particularly when the plots or areas are intended for demonstrations.

As far as possible, the style, form, and size of posts, pickets, and signs should be standardized, at least for a single station. The cost of establishing sample plots is sufficient to justify the use of well-made posts. The squared wooden post, 4 inches × 4 inches, 6 feet long, pointed at the bottom, and roofed at the top to prevent entrance of moisture and rot, is the most common type in use for plot corners. Unless of cedar, posts should be creosoted or otherwise treated to withstand rot. They should be painted white, aluminum, or light yellow. The addition of a black band at or near the top is an aid in locating them. Red will not long withstand the weather, and therefore should never be used.

Corner posts should be set two feet in the ground. Where the soil is shallow the posts should be well braced with rocks, stays, or anchor braces. The flat sides of the post should parallel the sides of the plot. The respective corner posts should be scribed or stencilled with the plot number and with large letters A B C, etc. (e.g., P.S.P. 51-A).

The post at the beginning of the tie-in line at the roadside should also be of corner post size. On this post, at Station No. O, the numbers of the plots for which the line is a tie should be scribed, stencilled or marked with aluminum tags.

Angle-iron or iron piping, with two galvanized iron plates 4 inches × 8 inches bolted to the top, make excellent corner posts. The disadvantages of these are that the plates often become twisted by wind, or are used for rifle targets. By splitting the pointed end of the angle iron the points spread when driven into the ground and thus become firmly set.

Pickets should be 2 inches × 2 inches × 3 feet, pointed and roofed. They should be driven 18 inches into the ground.

Pickets marking the corners of reproduction subplots should be painted white or yellow with a black cap to distinguish them from pickets used for other purposes. They should bear subplot number and corner letter (e.g., 1-A), stencilled or on an aluminum plate.

All-white pickets should be used for 20-foot subdivisions along boundary lines of sample plots, subdivisions of transect or other permanent plots, and for stations along tie lines, and should be appropriately numbered.

Large, appropriate signs should be placed on roadsides or at the entrance to important demonstration projects. These should bear brief descriptions of the project and the points under investigation.

INSTRUMENTS

The surveyor's compass on tripod, or the transit if available, should be used for bounding permanent sample plots and running tie lines.

Compass: The box compass may be used for line-plot surveys and for establishing transect sample plots.

Chains and Tapes: The surveyor's chain in links should be used for base lines and line-plot surveys, and may be used for transect sample plots. The 100-foot tape in feet and tenths should be used for permanent sample plot surveys and tie lines, and in measuring tree heights. Any interchanging with the surveyor's chain leads to confusion.

PHOTO. 10.—Corner post, 4 × 4 inches, roofed to prevent rot, and well supported by rock mound. (Photo. No. 19872).

PHOTO. 11.—Angle-iron corner post. (Photo. No. 27118).

Photo. 12.—Using Abney level on tripod as hypsometer. (Photo. No. 27119).

Diameter Tape: Diameters of all trees to be tagged should be measured with a diameter tape graduated in inches, tenths, and by means of a vernier, hundredths. Saplings and other untagged trees may be measured with calipers.

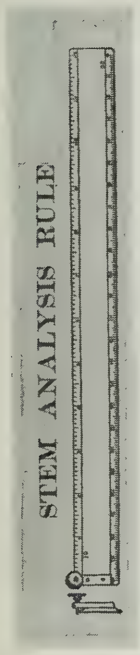
Calipers: Standard tree calipers, graduated in inches and tenths, may be used instead of the diameter tape for measuring diameters, except for tagged trees on permanent sample plots.

Abney Level: Abney levels may be equipped with topographic arc for use with the surveyor's chain, or with percentage arc for use with the 100-foot tape. Care must be exercised to select the correct arc. For permanent sample plot surveys and measurements of heights the percentage arc is required. For measurements of tree heights the Abney level must be set on a tripod.

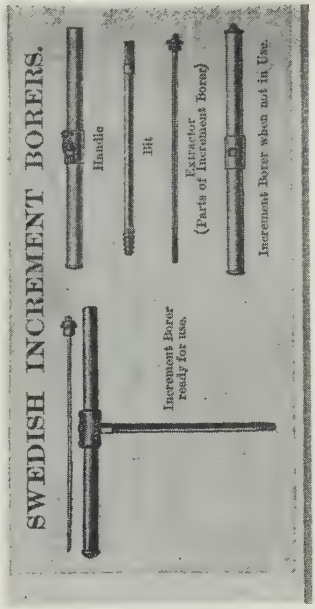
Increment Borers: These should not be less than eight inches long. Unsteadiness, likely in using short borers, tends to distort the core.

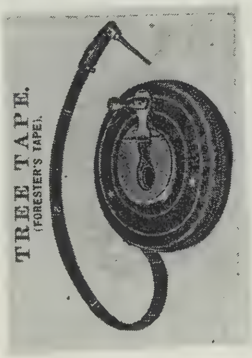
Cardboard Tubes for Borings: Use of cardboard tubes to hold borings is recommended when many borings are being taken. They may thus be taken to the laboratory for microscopic examination.

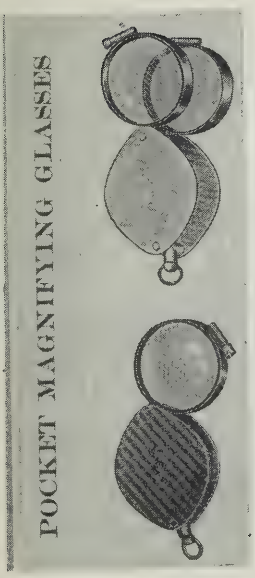
Magnifying Lens: A lens magnifying about five diameters should be used for field counts of growth rings.


STEM ANALYSIS RULE

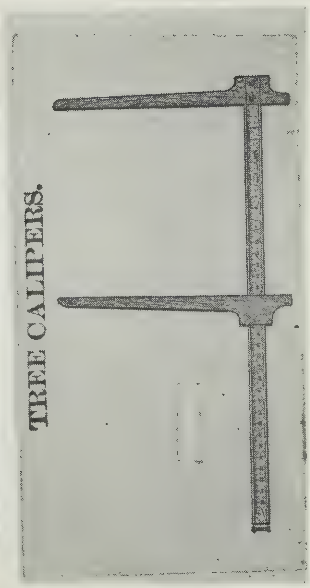

FORESTRY COMPASS


SWEDISH INCREMENT BORERS.
Increment Borer ready for use.
Handle
Bit
Extractor
(Parts of Increment Borer)
Increment Borer when not in Use.

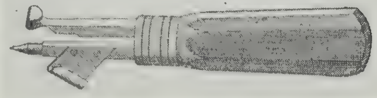

TREE TAPE.
(FORESTER'S TAPE).


POCKET MAGNIFYING GLASSES

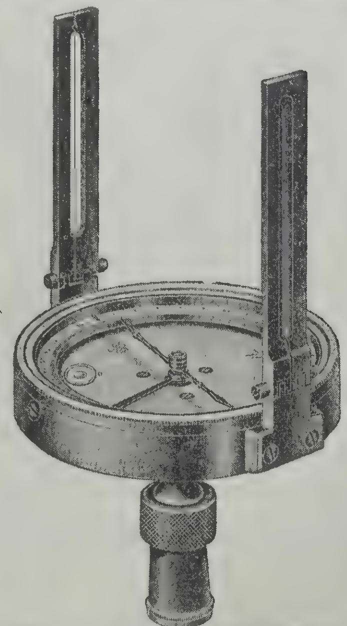

WOVEN TAPE


TREE CALIPERS.

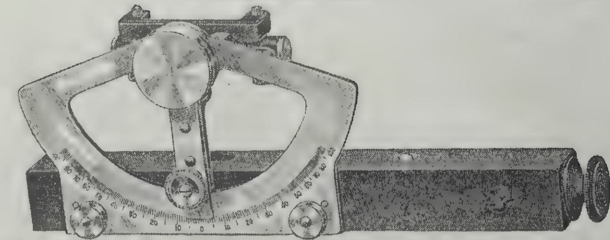
TIMBER SCRIBE.



SURVEYING COMPASS



ABNEY LEVEL



BAND CHAIN ON REEL

Electric Photometer: There are a number of exposure charts and meters adapted to ordinary photographic work on the market. However, the light value varies so greatly with variations in stand density that the electric photometer is the most satisfactory instrument for determining length of exposure in the woods.

ANALYSIS

The problem of analysing the data and presenting the results for publication is entirely the responsibility of the investigator. This work cannot, of course, be undertaken until data for all the plots or units of the project concerned have been compiled and summarized.

Each group of data should be examined, from as many angles as possible, for facts which may or may not confirm theories. Particular care must be exercised to be guided by facts rather than by preconceived ideas. When data appear to be at variance with theory or with the findings of other similar investigations, calculations should be carefully checked for possible errors.

When there are sufficient samples, data should be subjected to statistical analysis. Numerous textbooks on methods of statistical analysis are available, and it is not proposed to enter this field in the present publication.

Free use should also be made of graphical methods to iron out irregularities and to illustrate results on a comparative basis. Deductions and conclusions should be placed on paper and studied carefully before preparation of the final report is undertaken.

References:

1, 2, 4, 7, 9, 15, 16, 17, 18, 19, 28, 43, 44, 50, 51, 52, 53.

REPORTS

Establishment and Remeasurement Reports

At the close of the field season a concise report should be written and submitted to the organization responsible, stating what has been accomplished, and what work, if any, remains to be done to meet the requirements of the project plan. This report should be in sufficient detail to enable any investigator to pick up the work at any future date without loss of time and effort.

Interim or Final Report for Publication

A research project has little or no value until the data have been analysed and the results have been published. The writing of a good report on a technical subject is not simple. It should include both a statement of facts and an interpretation of them. Both facts and interpretation should be clearly and concisely stated.

"After writing the first draft of your article, begin to revise it. Revise many times, having one principal object in mind each time" (48). Objects to be considered are —consistency, clearness, repetition, connectives, euphony, punctuation, style, accuracy, and length.

After the draft has been thus revised, the manuscript should be prepared for the editor. This should be double-spaced. The forms of headings desired should be indicated by capitals, lower case, centre, side, or inset headings.

The manuscript should be submitted in duplicate, and one or more copies retained for file.

References:

29, 41, 48.

APPENDIX 1

Forest Terminology

It is axiomatic that ambiguity should, so far as possible, be eliminated in the field of research. Any terms whose exact significance may be in doubt should, therefore, be clearly defined. While correct definition is, of course, always desirable, it is of even greater importance that a given term shall have the same significance in all related references.

The terminology adopted by the American Society of Forest Engineers (45) should be followed as far as possible. Definitions in the appended list are, however, intended to replace, or to supplement, items in the above terminology.

Age Class.—That group of trees in a stand or forest whose age falls within stated limits; these limits are usually divided into 20-year periods, but in older stands may be of wider range. For yield table purposes, the limits should not exceed ten years.

Age Group.—For certain purposes, notably for less intensive studies, a stand of trees may be divided into four groups—reproduction, immature, mature, and over-mature. These are known as 'age groups.' The range of each group necessarily varies with the longevity of the species, but in general two series of ranges are recognized for Canada:—

1. Short-lived species, such as balsam fir, jack pine, white birch, and poplar: reproduction group, 1-20 years; immature, 21-40 years; mature, 41-60 years; overmature, over 60 years.
2. Long-lived species, such as white pine, red pine, spruce, larch, and tolerant hardwoods; reproduction group, 1-20 years; immature 21-60 years; mature, 61-120 years; overmature, over 120 years.

Diameter Class.—All trees of a stand whose breast height diameters fall within a one-inch prescribed limit, e.g. from 0·50 to 1·49 inch is the one-inch diameter class.

Exotic Species.—A tree or plant which is not indigenous to the region in which it is growing.

Even-age Class.—Stand in which 95 per cent of all trees one inch D.B.H. and over are within one age class.

Even-age Group.—Stand in which 95 per cent of all trees one inch D.B.H. and over are within one age group.

Forest Management.—This deals primarily with the economic and operational side of forest production—annual cut, cutting age, specific areas to be cut, and so forth.

Genetics.—Studies pertaining to the origin of strains and species of plants.

Immature.—A stand or forest which has not reached its utilization age; in Canada, for short-lived species, 40 years, for most long-lived species, 60 years.

Mature.—A stand or forest which has reached its utilization age and has begun to decline in growth rate; in Canada, for short-lived species, 41-60 years, for most long-lived species, 61-120 years.

Overmature.—A stand or forest which is declining in growth rate; in Canada, for short-lived species, over 60 years, for most long-lived species, over 120 years.

Ontogeny.—The branch of science dealing with life history of organisms.

Research.—Systematic investigation to discover facts or to co-ordinate them as laws.

Research Experiment.—A single unit in a research project.

Research Problem.—An obscure condition whose clarification would add materially to the knowledge of the subject.

Research Project.—Plan for dealing with a research problem.

Site Type.—The sum of the local factors influencing growth, such as climate, elevation, soil, slope, aspect, etc. Site types are classified in two ways:

1. By the vegetation associations. In this classification the type is designated by the names of the predominant herbaceous species, such as 'Viburum-Oxalis (Vi-O)', 'Oxalis-Cornus (O-Co)'.
2. By the height growth of dominant trees of a stated age. This type is simply designated 'Site I', 'Site II', or 'Site III'.

Small Growth.—Seedlings and saplings.

Stand Density.—An expression of the number of trees of a stated average diameter, per acre. The unit is the Stand Density Index (S.D.I.).

Stand Intensity.—An expression of the ratio of the volume per acre of wood produced to the cubic space required to produce it; the volume per acre divided by the average height of the stand.

Tree Classes.—Seedling: A tree less than 0·5 inch D.B.H. resulting from seed, sprout, or layer. Sapling: 0·5-3·5 inches D.B.H. Pole: 3·5-9·5 inches D.B.H. Standard: 9·5-23 inches D.B.H. Veteran: over 23·5 inches D.B.H.

Underbrush.—Large woody plants, young trees, or shrubs (not being part of the forest crop) which make up the lowest tier of forest vegetation other than the ground cover (25).

APPENDIX II

Legends

ABBREVIATIONS FOR TREE SPECIES

Abbreviation	Common Name	Botanical Name
Al	Alder	*Alnus.*
Ab	Ash, black	*Fraxinus nigra Marsh.*
Aw	Ash, white	" *americana L.*
Bd	Basswood	*Tilia glabra Vent.*
Be	Beech	*Fagus grandifolia Ehrh.*
Bw	Birch, white	*Betula papyrifera Marsh.*
By	Birch, yellow	" *lutea Michx.*
Bn	Butternut	*Juglans cinerea L.*
Cr	Cedar, red	*Thuja plicata D. Don.*
Cw	" white	" *occidentalis L.*
Chb	Cherry, black	*Prunus serotina Ehrh.*
Chr	Cherry, pin	" *pennsylvanica L.*
F	Douglas fir	*Pseudotsuga taxifolia (Poir.) Brit.*
E	Elm	*Ulmus.*
Ba	Fir, alpine	*Abies lasiocarpa (Hook) Nutt.*
Bam	" amabilis	" *amabilis (Loud) Forbes.*
Bf	" balsam	" *balsamea (L.) Mill.*
Bl	" grand, or lowland	" *grandis Lindl.*
H	Hemlock	*Tsuga.*
Hk	Hickory	*Carya.*
I	Ironwood	*Ostrya virginiana (Mill.) K. Koeh.*
L	Larch	*Larix.*
M	Maple	*Acer.*
Mh	" sugar, or hard	*Acer saccharum Marsh.*
Mm	" mountain	" *spicatum Lam.*
Ms	" red, or soft	" *rubrum L.*
O	Oak	*Quercus.*
Ob	" black	" *velutina Lam.*
Obr	" bur	" *macrocarpa Michx.*
Or	" red	" *borealis Michx.*
Ow	" white	" *alba L.*
P	Pine	*Pinus.*
Pj	" jack	" *Banksiana Lamb.*
Pl	" lodgepole	" *contorta Dougl. var. latifolia Engelm.*
Pr	" red	" *resinosa Soland ex Ait.*
Ps	" Scotch	" *silvestris L.*
Pw	" white	" *Strobus L.*
Py	" yellow, or ponderosa	" *ponderosa Dougl.*
Po	Poplar	*Populus.*
A	" Aspen	" *tremuloides Michx.*
Pla	" largetoothed	" *grandidentata Michx.*
Pb	" balsam	" *tacamahacca Mill.*
Cw	Cottonwood	" *deltoides Marsh.*
Cwb	" black	" *trichocarpa Torr. and Gray.*
S	Spruce	*Picea.*
Sb	" black	" *mariana (Mill.) B.S.P.*
Se	" Engelmann	" *Engelmanni Engelm.*
Sr	" red	" *rubra Link.*
Ss	" sitka	" *sitchensis (Bong) Carr.*
Sw	" white	" *glauca (Moench) Voss.*
W	Willow	*Salix.*
Wa	Walnut, black	*Juglans nigra.*

LEGEND FOR PRINCIPAL SUB-TYPES

Legend	Name
	Softwood Cover Type
B.S.	Balsam/Spruce.
Sb.	Black Spruce
P.S.	Pine/Spruce
Pj.	Jack Pine
Pl.	Lodgepole Pine
Pw. Pr.	White and Red Pine
Pw. Pr. Pj.	White, Red, and Jack Pine
C.L.	Cedar/Larch
	Mixedwood Cover Type
Bw. A-B.S.	Intolerant hardwoods—Balsam/Spruce
Bw. A-B.S.P.	Balsam/Spruce/Pine
Bw. A-P.	Pine
By M-B.S.	Tolerant hardwoods—Balsam/Spruce
By M-P.	" " —Pine
	Hardwood Cover Type
Bw. A.	Intolerant hardwoods
By M.	Tolerant hardwoods

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LEGEND

FINAL CROP TREES .... ◇
TREES CUT OUT .... ⊗
DEAD TREES .... ⊖
SEEDLINGS, 1918 .... P + Pine, Spruce, Balsam, etc.
SHOWING GROWTH .... ⊙ Since 1918.
WITNESS TREE .... ○ W.T.

PERMANENT SAMPLE PLOT I.

PETAWAWA FOREST EXPERIMENT STATION
Chalk River, Renfrew County, Ontario.
1938

Area: 0·841 Acre

Scales
For Plot: 1 inch = 10 Feet
For Trees 1/40 inch = 1 inch D.B.H.